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WITH DESCRIPTIVE AND HISTORICAL NOTES AND ILLUSTRATIONS

MINING AND ORE-DRESSING

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1920

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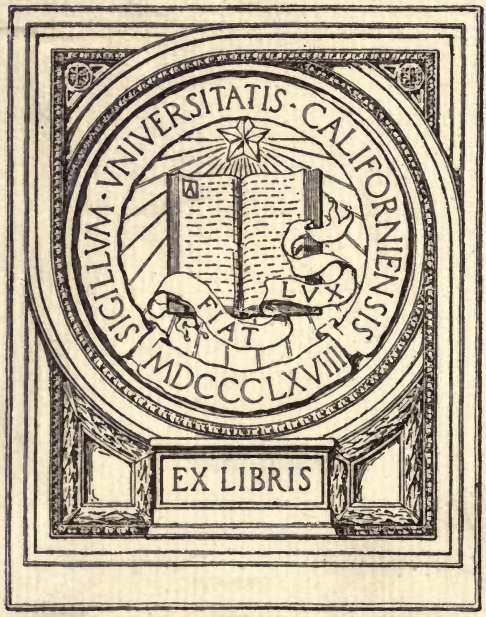
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PREFACE.

The Science Museum, with its Collections and Library, aims at affording illustration and exposition in the fields of mathematical, physical, and chemical science, as well as their applications to astronomy, geophysics, engineering, and to the arts and industries generally. To that end the Museum includes objects which are of historical interest as marking important stages in development and others which are typical of the applications of science to current practice.

A Museum of Science was contemplated as an integral part of the Science and Art Department from its beginning in 1853, and in 1857 collections illustrating foods, animal products, examples of structures and building materials, and educational apparatus, were brought together and placed on exhibition.

The first of the Engineering Collections, that of Marine Construction, was formed in 1864, when the Royal School of Naval Architecture was established at South Kensington, and the ship models belonging to the Admiralty were transferred to the Museum from Somerset House, where they had been previously. This Collection of ships of war was of great historical interest, and with the assistance of private donors and by purchase it was rapidly increased by the addition of many models of mercantile ships as well as of later ships of war, with the result that when the Admiralty removed their models to the Royal Naval College, Greenwich, in 1873, an important collection still remained at South Kensington. Engineering and Manufactures were first included in 1867, from which time the development of this portion of the Museum advanced steadily; but the transfer of the Museum of the Patent Office to the Department of Science and Art in 1883 added to the collection many machines of the highest interest in the history of invention and made it one of prime importance.

The collections of scientific instruments and apparatus were first formed in 1874, but it was only after 1876 that they became of importance. The Special Loan Collection of Scientific Apparatus which was held in that year in London brought together examples of all kinds from various countries, and a large number of these were acquired for the Museum.

In 1893 many Mining and Metallurgical objects, the collection of many years, were transferred to South Kensington from the Museum of Practical Geology in Jermyn Street, and these have subsequently been largely added to.

Mention should be made, too, of certain special Collections: The Watt Collection was presented to the Patent Museum in 1876 and contains original models made by James Watt; the Maudslay Collection, consisting of models of marine engines and machine tools, was purchased in 1900; and in 1903 a valuable collection of engine models, portraits, etc., was bequeathed by Bennet Woodcroft.

The Museum Collections are being continually added to by gifts and loans, and also by the purchase of such examples as are required to illustrate the application of science and the development of various types of instruments, machinery, etc.

NOTES.—A large number of objects in the Collections have been photographed. Selected prints from the negatives may be seen in guard books at the entrance doors. Particulars of available prints and lantern slides may be obtained by personal application at the entrances or by letter addressed "The Secretary, The Science Museum, South Kensington, S.W.7."

A compressed air service furnishes the power for driving such of the machines as are shown in motion, and the service is available daily from 11 a.m. (Sundays 2.30 p.m.) till closing time. Where practicable, these objects are fitted with self-closing air valves, by means of which Visitors may start them at will. Other objects are arranged so that Visitors may work them by other means, and there are a few that can be shown in motion only by an Attendant.

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CATALOGUE

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Numerical references in the text refer not to the page but to the serial numbers placed at the beginning of each catalogue title. When an object is illustrated, the reference to the plates of illustrations (bound at the end) is given immediately after the title. The number at the termination of each description is that under which the object is registered in the Museum Inventory. If the object has been photographed, the Inventory number is followed by the negative number, and where a lantern slide exists, the letters "L.S." are added.

MINING APPLIANCES.

Deep Boring.—It is usual, before commencing extended operations, to ascertain by borings of small diameter the nature of the strata to be traversed, and the depth and extent of the mineral deposit when reached. Much prospecting by mining is thereby obviated and the setting-out of shafts, cross-cuts and drives is expedited.

Two methods are used: Rotation and percussion. In the first method, in soft ground, shell or screw augers, rotated by hand or by power according to the depth, can be used. The connections to the tool, as the depth increases, are made by adding rods with screwed joints (*see* No. 1). The auger, when full, must be drawn up, necessitating unscrewing and screwing up again the line of rods. The loss of time thus entailed may be avoided by forcing down a current of water to carry up the fragments. Sometimes the lining tube is provided with a steel cutting edge and is itself rotated. The most important and widely-used boring tool of this class is, however, the diamond drill, the feature of which is the "crown," a short annulus of cast steel in which black diamonds are embedded in small cavities. The advantages of the tool are that it is capable of drilling through the hardest rock, and that the core made by it, when broken off and brought to the surface, shows the strata traversed (*see* No. 10).

In the percussive method, iron and wooden rods or ropes are used to actuate the tool. For shallow depths the rods are lifted by a winch and let fall by a trip gear; for greater depths a lever or spring beam is employed; for deep holes of large diameter a motor is used. In the Fauck and Raky methods rapid blows of short stroke are given (*see* No. 6), the sludge being continuously removed. With the rope method, winding can be done at a high speed—an economy in time over a line of rods, when the sludge pump has to be lowered, and an economy which increases with the depth of bore.

Excavating.—Picks, shovels, hammers, and wedges are most important excavating tools and have to be modified variously to suit the needs of different localities. Although space has not been found for their exhibition, a collection of such tools is available for reference. When a breaking-down agent is to be employed, boring and drilling by rotative or percussive action are resorted to. Screw

augers rotated and fed by hand (*see* Nos. 12—14) are commonly used in coal or moderately hard rock such as slate. The simplest percussive tool is a jumper or chisel used by its own weight or struck by a hammer. Its action is imitated on power-driven drills, which bore many times faster than hand work. The working fluid in rock drills is controlled by tappet or air-driven valves, or the drill may be valveless (*see* No. 21). Steam may be the working fluid in the open, but compressed air is used underground as it has the advantage of helping to ventilate the working place.

Blasting and wedging (*see* Nos. 41—45) are the chief means by which the drilled mass of rock is broken down. Gunpowder appears to have been used in mining early in the 17th century, but is now largely displaced, except when the rock is required in large blocks, by more efficient explosives which have a greater shattering action, such as those of the nitro-glycerine or the nitro-cellulose class (*see* No. 46).

Mine Timbering and other Supports for Excavations.—Underground passages and working places, with rare exceptions, will not stand unsupported indefinitely. The character of the support that must be used varies with the nature of the ground, the material adopted (viz., timber, masonry, or metal), and the form of the excavation (viz., vertical or steeply inclined "shaft," horizontal or inclined "level," or large and irregular "chamber"). Timber is most used owing to its comparative cheapness and the ease with which it can be worked. Its short life, danger from fire, and great bulk for a given load are its chief defects. Stone, brick, and concrete, built dry or with cement or mortar, are used for shafts and levels where their high first cost is more than compensated for by greater durability and low cost of upkeep. Water-tight masonry is used also in passing through water-bearing strata. Iron and steel are used for the same services and have the advantages of small bulk and weight in proportion to strength, and the possibility, in the case of steel props and caps, of use elsewhere; the scarcity of timber in some mining localities has led to an increased use of metal or reinforced concrete.

The form of support depends to a great extent on the nature of the pressure met with. In shafts pressure is met, in the case of timber, by rectangular sets or frames, closely spaced or with distance pieces, and having boards or poles behind when necessary to prevent loose ground falling in (*see* Nos. 52—60). In metal, the frames are circular or the lining is of continuous cast-iron segments. In levels, pressure may be met with in all directions, when a complete frame specially jointed becomes necessary (*see* No. 74). In metal, curved frames are sometimes substituted for the usual trapezoidal shape. In working places, logs placed upon one another, two by two, crosswise, form efficient supports (*see* No. 80). The square-set timbering so largely used in the United States consists in framing timbers in rectangular cells (*see* Nos. 91—96).

Systems of Mining.—The systems employed for the economic extraction of ores vary with the nature, depth, and extent of the ore deposits. The most important factor to be taken into account is the character of the containing walls or "country rock," i.e., whether it is good or bad standing ground. Another factor is the facilities that exist for obtaining timber locally. The general tendency is to use but little timber and to leave in pillars of barren or low-grade ore, the spaces between the pillars being filled in with waste rock.

The system that is adopted in a particular case may have to be designed specially to meet the conditions or it may be a modification of existing practice. A number of such systems that have been successful are illustrated; these range from underhand stoping for narrow veins (*see* No. 99) to the cut-and-fill system for wide ore deposits (*see* No. 103), with the necessary shafts, levels, winzes, rises and stopes.

Haulage and Hoisting.—Only those appliances exclusively used in mines are included in this section; others are placed with transport and lifting machinery in another section of the Collections. It should be noted too that pumps used in mining are grouped with pumps for other duties, in a general Pump Section. The common method of bringing a mineral to the surface is by means of a rope winding on a drum. Many forms of power are used for actuating it (*see* Nos. 116—124), necessitating some framework over the shaft for supporting the guide pulleys. The pit head frame is usually of timber (*see* Nos. 132—148), but where winding operations are extensive and the structure is to be permanent, steel frames are often erected (*see* No. 149). The receptacles used for raising the materials are :—buckets or kibbles, filled at the working place and hung on the rope loosely; boxes or skips, filled from a bin fed by wagons and working in guides—used more especially in irregularly inclined shafts; guided cages—the most general system—receiving the underground wagons and lifting them to the surface. In the last case the guides are vertical and the highest speed of winding is attained; the miners also can travel in cages. Much ingenuity has been expended on safety appliances for retaining the cage should the rope break, and for disconnecting the cage should it be overwound (*see* Nos. 134—147). Winding ropes are made of hemp, manilla, or steel wire, of circular or flat section.

Ventilating.—The air of mines is rendered impure by dust, and more particularly by carbon dioxide given off by burning lights, by explosives, by decaying timber, and in the breath of animals. In coal mines, especially, the strata also give off gases which form explosive mixtures with air and create serious dangers which can only be diminished by ventilation. Natural ventilation caused by the current of air produced by the difference of temperature that nearly always exists between the air of a mine and that of the external air where there are two shafts of unequal depth is the method generally relied on in vein mining. The want of constancy and of strength is a difficulty that has been met in collieries where considerable circulation is required by the simple and early expedient of heating the air by a furnace (*see* Nos. 154—156). Artificial ventilation on the large scale, however, is always effected by mechanical means, of which the centrifugal fan is the only appliance capable of dealing with the huge volumes of air required (*see* another section of the Collections).

Lighting.—Artificial illumination is a necessity at all times underground, and the means employed are candles, lamps, gas, and electric light. With the exception of safety lamps (*see* No. 160) these do not differ from the means adopted above ground, which are represented elsewhere in the Museum.

The electric light, although generally more costly, is so superior that more work can be done with greater immunity from accident by its aid than with any other illuminant. The incandescent lamp is most generally used in main haulage roads, and in isolated instances it has been adopted for the working places.

DEEP BORING.

1. MODEL OF BORING PLANT. (Scale 1 : 10.) Presented by Mons. Paulin Arrault, 1891. Plate I., No. 1.

This model represents a complete apparatus for boring holes of from 4 to 6 in. diameter to a depth of from 60 to 80 ft.

It consists of a tripod with tubular legs, one of which is combined with a single-purchase hand-winch, which is provided with a strap brake. The legs are connected at the top by an iron ring, through which the boring rods pass when being uncoupled. The chain from the winch passes over a pulley at the top down to a block with a swivel hook. The holes are bored by rotating augers if the ground be soft, and by percussive chisels in hard ground or rock. For this latter process the top length of boring rod ends in an eye in which a combined hook and lever engages. This lever is attached to the hook of the lifting chain, and also catches the eye of the top boring rod, so that when the chain is wound in the rods are raised. The master-borer, who is holding the end of the lever with his right hand, and the top of the rod with his left, rotates the rods a certain amount, and then, by depressing the lever, releases them. The rod, in falling, chips the bottom of the hole. The rods are again lifted by the assistant at the winch and the operation repeated. After a time the accumulation of chips necessitates the hole being cleared, which is done by withdrawing the rods and introducing a sand pump or sludger. This consists of a tube provided with a ball valve below, so that the sludge will readily enter but cannot return, and can thus be brought to the surface. The pump is alternately lowered and withdrawn until the hole is sufficiently cleared to continue the boring. Various forms of boring tools and earth augers are shown, together with the wrenches employed for screwing up and unscrewing the boring rods and tools.

(*See* Arrault, Outils et procédés de Sondage, 1890.) M.2409. 20,814 L.S.

A print adjoining shows trial boring by percussion being carried on in 1900 in the Furness district of Lancashire. M.4156.

2. BORING TOOLS. Made by Messrs. Clinton & Owens, 1865.

This is an outfit of tools for boring holes 2·5 in. diameter, by percussion or rotation. It includes: Swivel head; 10 ft. boring rod; spanner; flat and T chisels; shell and screw augers; spring hook and dart; sludge pump; bell screw for broken rods; crow's-foot for recovering rods; 3 ft. length of lining tube with bayonet joint, and 3 ft. length of lining tube with steel shoe. The connections are made by screws, the thread having a greater net sectional area than the rod has. The taper between the thread and the collar reduces liability to breakage. M.1406.

3. MODEL OF BORING PLANT. (Scale 1 : 8.)

This represents a hand-power plant for deep boring by percussion with rods. The topmost rod is attached by a chain and adjustable lengthening screw to a sector head on a jumping lever carried by a low timber framing. There are three positions for the fulcrum of the lever, so that the ratio of the arms can be varied. The rods are of iron, 1·25 in. square and in 15 ft. lengths, with screwed socket and end. For deeper sinking wooden rods are employed. For lowering and raising the rods a rope runs from a single-geared windlass over a pulley supported by an outer framing 35 ft. high, which carries also a windlass, pulley and lighter rope for actuating the sludge pump. M.2648.

4. MODEL OF DEEP-BORING PLANT. (Scale 1 : 12.)

Two lined bore-holes through various strata are represented to illustrate alternative free-falling cutter-bar arrangements for use when, owing to the depth of the hole, the weight of the rods becomes so great as to be destructive to the tool. The chisel (*see* adjoining case) is held on a short heavy rod, and, after being lifted a predetermined distance, is released.

In the method introduced by Mr. C. G. Kind in 1844, the chisel is lifted by two clip hooks with sufficient play on their supporting pin to shake clear when the rod is stopped.

In the arrangement of Mr. M. J. Degousée of 1853, the lifting clips are tripped by stops on a rod which is supported from the bottom of the hole.

(*See* Ann. Trav. Pub. Belgique, xviii., 171.) M.1407.

5. BORING HEAD. Constructed by Messrs. Mather & Platt, Ltd., 1894.

This tool is used in the percussive boring system originally introduced by Mr. C. Mather in 1854.

When in use it is suspended from the flat rope shown, which is wound on a steam windlass that will quickly lift the tool for cleaning out, etc. From the drum the rope passes over a pulley carried by the piston rod of a vertical steam cylinder, so that on the upstroke of the piston the boring head is lifted a distance equal to twice this stroke ; the valve gear then reverses and the tool falls and chips the bottom of the hole. To rotate the cutter so as to keep the hole circular, two crown ratchet wheels are fitted in the head and worked by teeth on the sliding collar by which the lifting rope is attached ; the result is that the cutter is rotated through the space of one tooth at each double stroke. The tool is 6 in. diameter and has four chisels, but holes up to 45 in. diameter are bored in this way and cores may be cut out to show the strata traversed.

(*See* Proc. Inst. Mech. Eng., 1869, 278.) M.2777.

6. MODEL OF PERCUSSIVE BORING PLANT. (Scale 1 : 10.) Presented by Messrs. Trauzl & Co., 1906.

This hand plant illustrates the " rapid " rope-boring system patented in 1898 by Herr A. Fauck, in which the cutting tool is arranged to give a large number of blows of very short stroke in a given time, the sludge meanwhile being continually removed from the hole by a current of water brought down through the hollow rods. The great advantage of this is that the time usually spent in removing the sludge by withdrawing the rods and putting down a sludge pump is saved, and this saving increases with the depth of bore.

The reciprocating motion is obtained from a pulley mounted eccentrically on a shaft, on which is keyed a flywheel with a rim brake ; this shaft is connected by gearing in the ratio 9 : 1 with a drum shaft turned by winch handles and a connecting rod. The rope or chain from which the boring rods is suspended passes over guide pulleys at the head of the boring frame and round the eccentric pulley, the end being attached to a barrel with a hand-wheel and worm gear feed. The rope is detached from this and hooked on to the drum when it is required to raise the rods.

By using toothed cutting edges and reversing the direction of the flushing current, cores can be obtained continuously without stopping work, as the vibration of the rods breaks off pieces which can be washed to the surface. A stuffing box in a cap provided with inlet holes screwed on to the top of the lining tube, as shown, then becomes necessary. With this method bores have been put down in the oil fields of Galicia to depths of 900 to 1,800 ft. at the rate of 30 to 36 ft. per diem.

The plant shown is suitable for depths up to 1,000 ft. ; the stroke is 2·2 in., and the speed would be about 250 strokes per minute.

(*See* Allgemeiner Bergmannstag in Teplitz Festbericht, 1899.) M.3459.

7. MODEL OF OIL-WELL BORING PLANT. (Scale 1 : 16.) Lent by Mrs. E. M. Falconer, 1918.

This model shows the " rig " adopted in Southern Russia, Baku district, in 1907, in boring by rope to depths of over 1,000 ft. for petroleum. The method of boring is of American origin, and is a development of that used in sinking artesian wells for obtaining water and brine.

A derrick is first erected consisting of four round timbers, 18 in. diameter at the butt ,braced diagonally with 9 in. square ties, and resting on timber sills. There are platforms at intervals, access to which is obtained by ladders. The height is 73 ft. and the base 24 ft. sq. An engine house of iron framing is also put up, the whole being roofed over with iron sheets. A timbered shaft is first sunk from the mud sill for about 10 ft. : then a drive pipe is driven till the rock is reached, and below this are the tube casings, 2·5 ft. diameter.

The string of drilling tools is suspended by a manila rope 2 in. diameter passing over a crown pulley at the top of the derrick. A temporary connection with the rope is made by an appliance known as the temper screw to a pitch chain from a walking beam. The latter is actuated by connecting rods from a winch which is so arranged that by means of sliding pinions either of two rope barrels can be driven as well as the walking beam. The first motion shaft of the winch

is belt-driven by a high-pressure simple engine, 30 in. diameter by 3·5 ft. stroke. The belt pulley or " bull wheel " is connected to the shaft by a clutch and has also a hand brake.

The distinctive feature of the drilling set is the use of an appliance introduced in 1831 by William Morris, known as the " slips " or " jars." This consists of a long double link with closely fitting jaws which slide freely on one another. This is interposed between the auger stem with its club bit and the sinker bar, its object being to give a sharp jar to the bit should it become jammed.

The operation is briefly as follows : When the string of tools has reached the bottom of the bore, the jars close and the cable slacks. The bull wheel now draws up the slack until the sinker bar rises, the play of the jars allowing it to come up about 12 in. without disturbing the bit. When the jars come together they slack about 4 or 5 in. ; the cable is then in the position to be clamped by the temper screw. The vertical movement of the walking beam is about 24 in., and on its up-stroke the sinker bar rises 4 in. The bit is picked up and lifted about 20 in. On the down-stroke the bit falls 20 in., while the sinker bar goes down about 24 in. to telescope the jars for the next blow. When the desired depth of hole has thus been made, the temper screw is released, the walking beam and its bearings are moved horizontally so as to be out of the way, and the tools are withdrawn by the rope. The sand pump for clearing the debris at the bottom of the hole—a cylinder having a non-return valve at the bottom—is then lowered by a rope from the second winch. Detailed models of some of the tools and appliances used are shown. A specimen of the oil-bearing earth, which is a friable sandstone, is shown also.

(*See* Boverton Redwood, Petroleum, I., 334.) Inv.1918-186.

8. MODEL OF OIL-WELL BAILING PLANT. (Scale 1 : 16.) Lent by Mrs. E. M. Falconer, 1918.

This model, made in 1909, only differs from the adjoining one in that it shows the arrangements adopted for bailing the petroleum after the latter has been reached by boring ; ordinary pumps are inapplicable owing to the large amount of sand present.

The derrick, etc., and engine that were used in boring remain, but the winch is replaced by one having a single rope barrel. The bailer is in the form of a long cylinder with a mushroom valve at the foot having a projecting stem. When the bailer is raised to the surface a plank is pushed over the hole. The valve stem resting on this is pushed up, allowing the bailer to discharge the oil and sand. To separate the sand a tank 7 ft. sq. by 6·75 ft. deep is placed on trestles over the bore. A launder leads the oil from it to the storage reservoir.

Specimens of oil from different bores are shown.

(*See* Boverton Redwood, Petroleum, I., 339.) Inv.1918-186A.

9. TOOLS FOR WITHDRAWING LINING TUBES. Made by P. S. Reid, Esq., 1865.

These are iron rods swelled out at the end to nearly the diameter of the tube to be withdrawn and brought to a point. A spring in the swelled part keeps a toothed stud pressed against the side of the tube when lowering, and when lifting causes it to catch under the end of the tube or against a socket.

(*See* Trans. N. of E. Inst. Min. Eng., x., 199.) M.1408.

10. DIAMOND DRILLING CROWN. Presented by John Thom, Esq., 1911.

The diamond drill is the most important tool for boring in hard rock by the rotative method. It cuts an annular hole, leaving a core which is broken off from time to time by a special tool, and brought to the surface to give information as to the strata being traversed.

The cutting part or " crown " of such a drill is shown, and consists of a short tube, in the end of which holes are bored at intervals from the inside to the outside of the annulus to receive Brazilian diamonds, that are held in place by riveting or punching the metal carefully round them. Longitudinal channels inside and out are left for allowing the pumped-in water to carry away the abraded particles. The crown is screwed internally for attachment to a boring tube, which is rotated at the surface, depending on the depth, by hand or by a motor working through gearing.

The diameter of the crown is 5·25 in. outside, and of the core produced, 4 in.; a sample of the latter is shown alongside.

In deeper bores, i.e. down to 4000 ft., the cores are 1·5 in. to 0·75 in. diam. The feed, varying with the hardness of the rock, is from 0·15 in. to 0·4 in. per 100 revs. M.3838.

EXCAVATING.

11. EMBLEMATIC MINING TOOLS. Received 1872.

Axes, such as these, are borne in procession as emblematic of their calling by the members of the miners' gilds in Saxony. They are dated between 1664 and 1749. The handles are engraved with views of mining operations.

M.1598.

12. "PEG" BORING MACHINE. Made by the Hardy Patent Pick Co., 1891.

This is an arrangement for using a screw auger for boring holes. A **V**-threaded screw, 22 in. long, 1 in. diameter, has at one end a handle and at other an auger; a nut on the screw is supported by the peg shown in a plank fixed at a suitable distance from the face. As the handle is turned the auger is automatically fed forwards while being rotated; the handle has two holes in it, so that when working near the roof it can be shortened. The augers are of several lengths, a short one being used to commence a hole, followed by two or three longer ones according to its depth; those shown are 24 in. and 42 in. long and bore a hole 1·5 in. diameter.

The defects of this simple drill are that its forward feed is invariable and is too quick for use in any but soft rock, while it takes almost as long to screw back to put in a longer auger as to screw forwards when boring.

M.1584. 20,889 L.S.

13. RATCHET DRILL. Made by the Hardy Patent Pick Co., 1891.

This machine is an improved auger drill. The screw is **V**-threaded, 1·25 in. diameter, 0·143 in. pitch, and 20 in. long; the nut, patented by Mr. A. E. Stayner in 1886, is in halves, which by means of a screw can be brought together. When the auger is boring the nut is closed, but when the auger is to be drawn back the halves are separated and the screw released. The screw is turned by a reciprocating handle and ratchet wheel, supported by an enclosing sleeve that bears against a wooden prop. The sleeve, to the front of which the nut is attached, is prevented from turning by a small crossbar attached to it, and bearing against an iron spike driven into the prop. The three augers shown are 18 in., 30 in. and 42 in. long respectively, and bore holes 2 in. diameter.

M.1591. 20,889 L.S.

14. "ELLIOTT" DRILL. Made by the Hardy Patent Pick Co., 1891.

In this auger drill, patented in 1888 by Mr. G. W. Elliott, there is a variable forward feed and a quick return. It may be used in comparatively hard rock, and thus has a wide application.

The usual nut is replaced by a worm-wheel kept in position by a brake, as in Whitworth's friction-feed drilling machine. When the brake is fully on, the screw moves forward the full extent of its pitch, but when the brake is free the worm-wheel turns idly and the feed screw, when rotated, does not advance, but conversely the feed screw can without rotation be rapidly pulled back or pushed forwards; between these two extremes any amount of feed can be obtained by tightening up the worm-wheel. The feed screw is 1·625 in. diameter, 27·5 in. long, and has a square thread of 0·5 in. pitch. The three augers shown are 18 in., 36 in., and 54 in. long respectively; the machine is worked by a reciprocating handle turning a ratchet wheel, and bores a hole 1·875 in. diameter.

The machine is provided with an abutment or stand, made in halves, so that by shifting a pin its length can be altered to suit the height of the working place. M.1585. 21,018 L.S.

15. MODEL OF BORING MACHINE (Scale 1 : 4) AND FOOD CARRIER. Lent by T. Hurry Riches, Esq., 1896.

In April 1877 fourteen miners were entombed at the Tynewydd Colliery, Glamorganshire, by the inrush of water from an adjacent working; nearly all these men were ultimately rescued, several by the removal of the water by pumping. Five of the latter had taken refuge in a rise heading. An air-locked hole was made through the solid coal by a boring machine, represented by the model, and food in a liquid form supplied to them in pointed canisters provided with supporting wheels, as seen in the specimen preserved. The boring machine was a hand-worked geared tubular drill with a screw feed. Both it and the carriers were designed and made by Mr. Riches.

M.2961. 20,802 L.S.

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16. MODEL OF HAND-POWER ROCK DRILL. (Scale 1 : 3.) Constructed by Messrs. T. B. Jordan & Sons.

This is a later form of a drilling machine patented by Messrs. T. B. Jordan & J. Darlington in 1866; it is driven by hand-worked winch handles, but the blow is delivered by an air spring.

A frame with four adjustable legs carries two hand fly-wheels and a vertical cylinder; the cylinder is fitted with an air-tight piston and a long hollow piston rod, through which passes a feeding screw connected with the drill. By a shoulder on the upper end of the piston rod the screw is lifted by a cam on the fly-wheel shaft, so compressing the air above the piston and at the same time rotating the drill by an inclined toothed ring. When at the top of the travel the cam leaves the lifting collar, and allows the piston and drill to spring forward under the action of the compressed air. The feeding is performed by a hand wheel and bevel gear, that rotates a nut on the feed screw. In a later arrangement the machine was much simplified and the feed was given by a toggle grip that allowed the long drill to creep forward while at work.

M.2820. 20,784 L.S.

17. MODEL OF " INGERSOLL " HAND-POWER ROCK DRILL. (Scale 1 : 2.) Lent by Messrs. Clark & Wellington, 1887.

In this machine, as the fly-wheel handle is turned the drill is lifted by cranks and a strong helical spring is compressed; as soon as the cranks have passed the top centre the spring drives the drill down rapidly, the cranks running freely forward under the action of the spring owing to the crank shaft being able to overrun the fly-wheel, through there being only a ratchet-wheel connection. The drill is turned automatically by means of a rifled bar, round which the spring is coiled and which rotates it during the up-stroke. The feed is given automatically or by hand; in the former case a swelling on the drill bar acts as a tappet to strike a lever which, by means of a pawl, rotates a ratchet-wheel arranged just below the handle which is used when feeding by hand.

Hand-power drills never had an extended use because they offer no advantages over the simple hand methods. M.1867. 20,787 L.S.

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18. PORTIONS OF EARLY ROCK DRILL. Presented by G. Green, Esq., 1902. Model (scale 1 : 8) made in the Museum, 1903.

This example of a percussive rock drill, to be driven by compressed air or steam, was made in 1863 by Mr. G. Green, under the patents of Mr. E. S. Crease, and used at the Clogau Mines, North Wales; it is believed to have been the first machine of the class to be practically worked in this country. It was favourably mentioned by the Royal Commission on Mining in 1864; but owing to there being no air-compressing machinery available at that date, steam was used as the motive power, and this restricted the employment of the drill to short or open workings.

The machine consists of a cylinder having a piston and rod carrying the boring tool, while at the end of the piston rod are two tappet collars which actuate the valve and also the gear for feeding and turning the tool. A forked lever, whose upper ends engage with these collars, is pivoted to an arm on the cylinder and drives the valve from its lower end, while from another point in

it the turning and feed gears are driven by means of rods and levers. The turning is performed by a ratchet-wheel, which rotates a spindle passing through the cylinder cover and into the piston rod, where there is a feather connection. The cylinder is carried in slides, containing a nut through which passes a feed screw, secured to the cylinder and rotated by change wheels from the ratchet-wheel above.

To enable holes to be drilled in any position or direction the cylinder slides are attached, by a swivel connection, to the end of a sliding bar, which passes through a sliding socket embracing a vertical pillar. This pillar is carried on a four-wheeled iron truck and has a swivel-headed screw at its upper end for strutting the machine from the roof; rack and pinion gear is, moreover, provided for raising the socket up the pillar.

The cylinder is 4·25 in. diameter by 4 in. stroke, and with a steam pressure of 15 lb. per sq. in. the drill delivered 400 to 500 blows per minute; it is stated that in average rock the holes were drilled at the rate of 1·5 in. per minute. The portions shown of the actual machine are the cylinder, slide, and sliding bar with its socket; the model represents the complete machine, which weighed about 15 cwt.

(*See* Min. Journ., 1864, 806.) M.3245. 26,751 L.S.

19. "BARROW" ROCK DRILL. Made by Messrs. M. Loam and Son, 1894.

This is a full-sized model in wood of an early successful drill for working by steam or compressed air; it was patented in 1874 by Messrs. R. Hosking and W. Blakewell. The machine consists of a cylinder fitted with a long double piston, to the projecting rod of which the bit is attached. Centrally in the piston is a spherical swelling, which acts as a tappet to oscillate a double slide valve capable of turning on a central pin. The rotation of the drill is performed by hand, through a central spindle which fits a hole in the piston and by means of a feather transmits the rotation without interfering with the free reciprocation of the piston.

The cylinder is carried in a slide attached by swivel connections to a support, usually formed of an extensible strut which can be fixed across the level. Between the guides is secured a nut, in which works a screw connected by gearing to the hand shaft, so that the movement that rotates the drill also advances it.

(*See* Engineering, 1885, ii., 446.) M.2655.

20. "ECLIPSE" ROCK DRILL. Presented by Messrs. Hathorn and Co., 1885.

In this machine the distributing valve is of the pressure-moved type. The drill is clamped into the piston rod of a small direct-acting cylinder, and to the cylinder is bolted a small valve box containing a piston valve. The main piston is long, and when at the extremities of its stroke, opens communication alternately with opposite ends of the piston valve, and in this way the motion of the piston moves the slide valve so as to cause the reverse motion, the action being so quick that several hundred blows per minute are regularly delivered. The simultaneous rotation of the drill is secured by a rifled bar working in a nut in the piston and controlled by a ratchet-wheel at the cylinder end. The cylinder is carried in a cradle, fitted with a double swivel and three adjustable legs so that the drill may be pointed in any direction, while a screw fixed to the cradle and engaging in the nut on the cylinder enables the drill to be fed forward by hand. The cylinder nut, however, is provided with ratchet teeth, into which a pawl driven by a vertical rod that receives motion directly from the piston engages, and so automatically feeds forward the whole cylinder. M.1628. 21,073 L.S.

21. DIAGRAM MODELS OF THE "ADELAIDE" ROCK DRILL. (Scale 1 : 4.) Received, 1891.

These represent in section the cylinders of what is known as a "valveless" drill, the piston by its motion distributing the working fluid; the drill was patented in 1881-2 by Mr. G. F. Wynne.

The air is always at full pressure in the annular port at the front end of the cylinder. When the piston is moving forwards, air is being admitted to the back of the piston through a hole in the hollow piston rod; the air is soon cut off by the hole being covered, and the remainder of the stroke is completed by expansion. Exhaust takes place at the front end through the hole formerly admitting air,

and also through the exhaust hole in the hinder part of the cylinder. Simultaneously air is admitted to the front of the piston through a broad hole cut in the piston. The turning is done automatically by a rifled bar and ratchet-wheel, but the feed is by hand. M.1587.

22. FRANKE'S MECHANICAL CHISEL. Made by Messrs. Friemann & Wolf, 1894.

This is a percussive machine, patented in 1890 by C. Franke, for undercutting in rock. It performs its work by striking some thousands of light blows per minute, under the action of compressed air conveyed by a flexible pipe, and, as it can be held in the hand, it is exceedingly portable. The inertia of the machine at this high speed appears to prevent any reaction being felt by the miner.

It consists of a steel barrel fitted at the front end with a tool holder, which is forced backwards by a spring. In the barrel is also a plunger that is forced to and fro by the compressed air, and at the extremity of the forward stroke strikes the tool holder, by which the blow is transmitted to the chisel edge. The air is distributed, and cut off so as to act expansively, by a small slide valve in the form of a ring which fits in a recess in the plunger. The exhaust takes place through the centre of the plunger and the slide valve, which is worked by air pressure, places one end of the plunger in communication with the air supply and the other with the exhaust, the resulting motion of the plunger carrying the valve to the other side of the air supply port and so causing a movement of the slide which reverses the action. Air at 60 lb. pressure is used, and the stroke of the chisel is 0·06 to 0·08 in.; the chisel is of 0·5 in. round steel; the machine weighs 10 lb., and can undercut to a depth of 2 ft.

Another specimen of this machine is shown in which, by a rifled bar arrangement, the tool holder is rotated as the reciprocation proceeds, so that holes may be drilled. M.2555-6. 20,891 L.S.

23. MODEL OF "OPTIMUS" ROCK DRILL. (Scale 1 : 4.) Presented by Messrs. R. Schram & Co., 1893.

This represents in section the cylinder and valve of a drill patented by Mr. P. J. Ogle in 1891. The drill is driven by steam or compressed air, and works as a compound engine; the fluid first acts on the back of the piston, driving it forward, and then the same charge, acting on the front, performs the return stroke. The piston is a double one of two different diameters, and the space between the two portions is always open to exhaust; the front portion is the larger. The valve is on the side of the cylinder and is moved by the working fluid. During the forward stroke, air is acting behind the small piston, while the rest of the chambers are free to exhaust; but when the limit of the stroke is reached the small piston uncovers a port that admits air that moves the slide valve. The slide valve, after cutting off the supply to the piston, opens a passage from the small cylinder to the front end of the big one; the air then acts on a larger area, and so drives the piston backwards while expanding. The rotation of the drill is performed by the usual rifled bar and ratchet wheel; the feed is given by hand. M.1586.

24. "DAW" ROCK DRILL. Lent by Messrs. A. & Z. Daw, 1898.

This is an air or steam worked percussive drill, patented originally in 1887 by Messrs. A. W. & Z. W. Daw, in which the external distributing valve is moved by the working fluid.

The piston is of exceptional length and has a recess around it that is always in communication with the fluid supply pipe. When the piston reaches either end of its stroke, this recess admits the working fluid into ports that convey it to the ends of the external slide valve, which is of the piston type; in this way the piston, on reaching the end of its travel, causes the slide valve to move in the direction necessary to ensure the return stroke of the piston. The rotation of the drill is given by the usual rifled bar and ratchet wheel, while the feeding is performed by a hand-worked screw (*see* sectional drawing).

The cylinder carriage is provided with a swivel head which is clamped to a sleeve that fits on a bearing formed on the head of a tripod; by this means the drill can be set to work in any direction. In the support shown the legs are fitted with heavy weights, as usual when quarry working. M.3022.

25. MODEL OF PORTABLE ROCK DRILL. (Scale 1 : 8.) Made by the Ingersoll-Sergeant Drill Co., 1904.

This is a percussive rock drill to be driven by steam or compressed air, and is a development by Mr. H. C. Sergeant of a drill invented by Mr. S. Ingersoll in 1872.

The chisel is clamped into the end of the piston rod of a direct-acting cylinder, to which is bolted a valve box containing a pressure-moved distributing valve, actuated by differences in pressure, caused by an auxiliary tappet valve moved by the piston. The cylinder ends are retained in position by two long tie rods acting through plate springs which serve as buffers when the stroke is excessive. The rotation of the drill is secured by a rifled bar engaging with a nut in the piston and controlled by a ratchet ring at the cylinder head ; this ratchet ring is, however, only retained by the pressure of the buffer springs and will slip when excessive resistance to turning is encountered. The drill cylinder is 3 in. diameter by 6·5 in. stroke, and with a pressure of 60 lb. per sq. in. gives about 350 uncushioned blows per minute. It drills holes from 1·5 to 2·25 in. diameter up to 14 ft. deep, the average work in granite for vertical holes being 70 ft. in 10 hours.

The cylinder is carried by a cradle in which it slides when the feed screw is worked by the attendant, and the whole drill is attached to a tripod by a universal joint so that it may operate in any direction. The tripod has weighted telescopic legs, two of which are provided with universal joints, but when working in underground headings the drill is generally mounted on a single column, which is shown detached. M.3316. 26,271 L.S.

26. MODEL OF "IMPERIAL" ROCK DRILL. (Scale 1 : 4.) Lent by The Climax Rock Drill & Engineering Works, Ltd., 1915. Plate I., No. 2.

This is a percussion compressed-air rock drill of the arrangement now usual, but embodying some special features patented between 1896 and 1908 by Messrs. R. and W. C. Stephens.

The cylinder is readily accessible, the ends being held by two tie bolts 0·5 in. diameter with plate springs as buffers. The front end is split with renewable bushings to admit the piston rod, which is small at the end and slotted to take the drill bit. This is clamped by a **U** bolt with a wedge and pad combined in one. The valve is of the auxiliary pressure-moved type. The cradle slides are **V**-shaped with a means for taking up wear. The drill is fitted with a dust allayer giving a radius of 3 ft. around the bore hole and using about 1 gal. of water in 5 to 8 minutes. This is arranged to come into operation when the air pressure is turned on. The air hose is provided with a rapid coupling attachment and valve combined ; when the coupling is pushed on to the nipple, a trigger drops into a recess between the collars of the nipple and opens the air valve. The coupling is detached by simply lifting the trigger when the air is cut off.

The drill is made in four sizes ; the one shown has a cylinder 3·25 in. diameter by 6 in. stroke, weighs 280 lb., and is stated to be capable of drilling holes 1·5 in. diameter in granite at a speed of 0·25 to 0·35 ft. per minute.

The drill is shown mounted on a cross arm 4·5 in. diameter and 4·5 ft. long at right angles to a tunnel bar placed in a model to represent the lode, etc.

Inv.1915—81. S.M. 1267.

27. MODEL OF HOLMAN ROCK DRILL. (Scale 1 : 4.) Presented by Messrs. Holman Brothers, Ltd., 1914.

This percussive compressed air drill is the outcome of many years' experience, and embodies features patented in 1907 by Messrs. J. H. and J. M. Holman.

The cylinder accommodates a long leather-packed piston hollowed out to receive the rifled bar, which, with its ratchet ring and pawls, is arranged so that it can be quickly taken apart. The split front head with renewable half bushings enables the packing to be replaced in a few minutes. The end of the piston rod is slotted to take a half-round bush, between which and a pad the drill bit is clamped by a **U** bolt tightened by a wedge. A blow on the latter loosens it and quickly releases the drill ; after a new one is inserted the first few strokes of the piston tighten it again. The valve is of the auxiliary pressure-moved type (*see* No. 28). The cradle has the usual feed screw arrangement ; the slides are **V**-shaped with means for taking up wear. The cylinder is of hard cast iron, while other parts are of different grades of steel to suit the hard usage to which these machines are subjected.

The whole is mounted on a tripod, the arrangement used for open workings and for places in the mine where the column is inapplicable. The legs are telescopic and adjustable to any angle. To steady the tripod, weights varying from 150 to 400 lb. are saddled on arms clamped to the legs.

The drill is made in a large number of types and sizes ; the standard E size, of which this is a model, has a cylinder 3·25 in. diameter by 7 in. stroke. The length of feed is 27 in., and it will drill easily a hole starting at 2·5 in. diameter to a depth of 16 ft. The weight unmounted is 295 lb. With six drills of this size at Van Ryn Deep during August, 1910, a distance of 279 ft. on an inclined shaft 20 ft. by 7·5 ft. was accomplished, constituting a record.

In the South African Stope Drill Contest of 1909-1910 a light machine, differing but slightly from the above, was successful in obtaining the first place. Inv. 1914—737.

28. MODEL OF VALVE MOTION OF ROCK DRILL. Presented by Messrs. Holman Brothers, Ltd., 1914.

This illustrates the valve motion of Holman's standard air-drill (No. 27) ; it is of the auxiliary pressure-moved type.

The common D slide valve with piston ends which distributes the air to the ends of the piston is controlled by ball valves projecting through the cylinder wall into a waist in the middle of the piston. As the piston reciprocates an incline at the end of the waist lifts one ball and with that another ball, which is the actual valve that opens to exhaust the space at the opposite end of the slide valve through grooves on the valve face. A moment later the corresponding ball at the other end comes down on its seat under the action of its spring and closes to exhaust. The valve being now in such a position that air can get through the groove in the casing to the back of the other end, an unbalanced pressure is created, and this forces the valve over. Inv. 1914—738.

29. MODEL OF ROCK DRILL STAGING. (Scale 1 : 8.) Made in the Museum, 1919.

This shows a simple and easily adjustable staging for supporting a rock drill.

In the process of exploiting veins of medium width the ore on the floor of the working gives the miner sufficient elevation for stoping out the first and second "cuts." For succeeding cuts, and in ore deposits of considerable width generally, scaffolding such as that shown by the model must be resorted to. In narrow veins, of course, staging may be accommodated by fixing bearers across from foot-wall to hanging-wall.

The scaffolding shown is composed of vertical posts, 6 in. diameter, wedged tightly in position. On each post at every 12 in. above breast height, sets of holes 1·5 in. deep are provided to take pointed grips 5·25 in. by 4 in. by 2 in. In the grip hangs a hook of iron, 1 in. or 0·875 in. diameter by 17 in. long and 8 in. wide, so as to embrace the post. In the hook and against the post rests a horizontal bearer, 6 in. diameter, and this in turn supports a platform made of 8 in. by 2 in. timber. The dimensions of the staging are varied to suit each particular case. Inv. 1919—226. S.M.1044.

30. MODEL OF QUARRY BAR ROCK DRILL. (Scale 1 : 8.) Made by the Ingersoll-Sergeant Drill Co., 1904.

This consists of an ordinary rock drill mounted on a long bar supported by four legs. It is for use in quarries where straight rows of holes are required, for breaking rock, or for broach channelling in granite or other rock too hard for a channelling machine.

The bar is a hollow cylinder, provided with a rack along its upper part and a feather along the lower surface. It is attached by clamps to two cross-heads having at their ends swivelling sockets for securing the supporting adjustable legs, which are weighted. The drill is attached, by a universal joint, to a sliding sleeve which may be placed at any part of the bar, and the sleeve can be traversed along the bar by hand through a pinion gearing with the rack.

The bar is 4·5 in. diameter and 12 ft. long. The drill represented is described in No. 25. The total weight of the machine is 1,730 lb. M.3317. 26,266 L.S.

31. MODEL OF BAR CHANNELLER. (Scale 1 : 8.) Made by the Ingersoll-Sergeant Drill Co., 1904. Plate I., No 3.

This machine is for cutting deep grooves in rock, preparatory to removing the stone in blocks by wedging or blasting, and is a combination of a rock drill with a special form of portable double bar frame, patented in 1889 by Mr. H. C. Sergeant.

The frame consists of two cylindrical guide bars connected at the ends by trunnion pieces, which are carried in crossheads having at their ends swivelling sockets for receiving two adjustable legs. These legs, which are provided with steel points and lifting sockets, are held down by removable weights. The drill cylinder is mounted in a cradle, down which it is fed, as required, by hand, and the end of the piston rod is attached to a guided crosshead carrying a gang of chisels. The cradle is secured to a saddle fitting the guide bars and traversed along them by a small three-cylinder engine, which rotates a nut engaging with a stationary screw parallel with the bars. This traversing motion is automatically reversed at the ends of the travel, and it has a friction drive which slips under any excessive stresses.

Work is commenced by drilling a circular clearing hole at each end of the intended groove. The drill chisel is then removed, and a gang, or group of chisels in one plane, substituted, by which the groove is gradually chipped out as the cradle moves to and fro along the guide bars. Owing to the guide bar crossheads being carried in trunnions, the machine can be set at any desired inclination.

The drill represented is described in No. 25. The travel of the machine is 8 ft., and it is designed for cutting channels to a depth of 7 ft. The working capacity is from 60 to 100 sq. ft. per day, and the weight of the complete machine is about 3,000 lb. M.3318. 26,267 L.S.

32. MODEL OF TRAVELLING CHANNELLING MACHINE (Scale 1 : 8.) Made by the Ingersoll-Sergeant Drill Co., 1904.

This machine, for cutting vertical channels in rock, was introduced in 1893 and extensively employed for cutting the sides of the rock excavations of the Chicago Drainage Canal. It consists of a large percussive drill, mounted on a self-propelled four-wheeled truck carrying its own boiler and running on a portable railway. The steam to the drill piston is distributed by a pressure-moved piston valve, whose motion is determined by an auxiliary valve moved by a tail-rod. The cylinder, with a crosshead to which is clamped a gang of chisels in one plane, is carried in a cradle bolted to a vertical plate firmly attached to the truck. The drill overhangs the side of the truck, and is fed downward by a screw rotated by a small three-cylinder engine. The whole machine is moved to and fro along the track, as the gang of chisels are chipping away the rock, by means of another three-cylinder engine, which drives the axles by worm gearing and a friction clutch, so as to prevent damage should excessive resistance be encountered.

The boiler is vertical, and, in addition to being bolted to the truck, is guyed by elastic stays. The steam connections to the drill cylinder are made by telescopic and swivelling pipes which permit of the drill being placed in any position on the vertical plate.

The machine usually cuts channels from 4 to 7 ft. deep, and from 30 to 50 ft. long, but the depth may be increased to 14 ft. The gauge of the track is 4·8 ft. outside, and the weight of the machine is about 9,000 lb. (4·25 tons).

M.3319. 26,265 L.S.

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33. HAMMER ROCK DRILL. Lent by Messrs. Ironside, Son and Dyckerhoff, 1911.

This is a form of percussive drill in which the piston, instead of being attached to the boring bit, hammers continually on its end as in the pneumatic hammer. The application of the idea to mining, though of some long standing (*see* No. 22), has only recently been widely extended. Compared with the reciprocating type, the hammer drill strikes less powerful and more frequent blows, but this permits reduction in weight so that the time which would be needed for setting up is occupied in actual drilling; with deep holes there is a saving in the dead weight of boring tools lifted.

The drill shown, known as the "New Century," in common with others of this type, has the boring bit held in a hollow chuck, which is carried round as usual by rifling in the piston rod in its outstroke, but is held stationary on its instroke by a ratchet-wheel and pawls.

The piston serves as its own valve, a recess in the piston opening alternately to back and front ports of the working cylinder; the air is used expansively and therefore economically. Part of the exhaust passes through the piston rod, down through the tool and blows the debris out of the hole. A spring handle is fitted to take off vibration from the operator's hands.

The cylinder is 2·95 in. diameter; the piston has 1·9 in. stroke and strikes about 1,500 blows per minute, consuming in that time 33 to 35 cub. ft. of free air at 60 to 70 lb. pressure. The tool weighs 40 lb.

The speed of drilling varies, according to the nature of the rock, from 2 to 9 in. per minute; depths up to 20 ft. can be drilled.

A section of the drill (scale 1 : 2) and photographs showing different uses are shown. M.3843.

34. HAMMER ROCK DRILL. Presented by The Flottmann Engineering Co., Ltd., 1913.

In this type of percussive drill the action is the primitive one of striking a chisel with a hammer, only that in place of the hammer there is a free piston reciprocating in a cylinder. The idea was first adapted to mining at Mansfield, in Germany, but it was not till a satisfactory method of rotating the chisel was brought out that the drill became a success.

The hammer drill occupies a field which the larger piston drill does not economically fill. It is a hand tool which can be used in narrow veins, small stopes, &c.; it delivers a large number of light blows which are as effective as a smaller number of heavy blows, but not so destructive of the drill steel. It drills small holes which are economical in explosive and its speed enables it to oust hand drilling.

In the drill shown, the cylinder cover, which is in one with the handle, is held by two long bolts to an extension piece with the cylinder between; helical springs on the bolts obviate breakage should the piston accidentally strike the end of the cylinder instead of hitting the chisel. This extension piece contains the rotating mechanism patented in 1906 by Mr. H. Flottmann. Within the piece projects the piston rod part of which has four longitudinal grooves and part has four helical grooves cut in it. Surrounding the latter is a ratchet ring with pawls, while the straight grooves slide in the drill holder. Thus on the up-stroke of the piston the pawls prevent the ratchet ring from turning and therefore the piston and with it the drill holder must turn, while in the down-stroke the pawls allow the ring to turn and a straight blow results. The drill is held in the drill holder by a coil spring on the extension piece forming the chuck.

The valve is of the pressure-moved type patented by Mr. Flottmann in 1904. It is a steel ball with a stroke of about 0·06 in. When the ball is on one seat air enters the opposite end of the cylinder and drives the piston along till it uncovers an exhaust port; the reduction in pressure lets the ball fall on its opposite seat, air is then admitted to the opposite side of the piston which is thus brought to rest and finally driven in the reverse direction till it uncovers the exhaust port at that end.

All the parts of the drill are of steel, drop-forged or cut from the solid and casehardened. The cylinder is 2·375 in. diameter, the piston has a stroke of 2·125 in. and strikes about 2,000 blows per minute, consuming about 25 cub. ft. of air at about 70 lb. pressure. With it holes can be drilled up to 2·5 in. diameter, and 10 ft. deep. The tool weighs 25 lb.

Twist and hollow drills can be used with this tool; examples of both kinds are shown. Inv. 1913—2.

35. "HYDROMAX" HAMMER DRILL. (Scale 1 : 3.) Lent by The Climax Rock Drill & Engineering Works, Ltd., 1915.

This is a percussion hand drill of the arrangement now usual but embodying some features patented in 1908-9 by Mr. W. C. Stephens.

The cylinder ends are held on by coiled springs. The valve is of the pressure moved type. The air hose has the rapid coupling described with the adjoining model (*see* No. 26). The drill bit has Stephens's parallel double chisel point.

The drill is made in 3 sizes; the size represented is 2·06 in. diameter by 3·5 in. stroke, weighs 50 lb., and is capable, with an air pressure of 90 lb. per sq. in., of drilling 2·5 in. per minute in diorite or 12 in. in granite. Inv. 1915—82.

36. MODELS OF CIRCULAR COAL-CUTTING MACHINES. (Scale 1 : 4.) Contributed by C. H. Waring, Esq., 1875.

These machines were patented by Mr. Waring in 1852 "for cutting coal, shale, &c. in coal pits." Although they did not come largely into use, similar machines driven by compressed air have since been employed with considerable advantage in working thin seams.

In the first machine a thin horizontal wheel with four projecting double teeth is rotated by bevel gear driven by two men who, by hand levers and connecting rods, drive two cranks at right angles. The axis of the cutting wheel is carried on a frame that slides in guides on a trolley that can be lifted off its wheels by four screwed legs. The frame, carrying with it the disc, is automatically forced forward along the guides by rack and pinion, driven by worm gear from the main shaft.

In the second machine, two saws are arranged on a horizontal axis, so that they make two vertical cuts such as would be necessary for the sides of a level. The axle of the saws is mounted in a frame that can be elevated while at work and this frame is carried in slides on a four-wheeled carriage. The saws are rotated at considerable speed by gearing, driven by two men at reciprocating handles as before, while the frame is automatically advanced along the slides by a ratchet feed. The trolley wheels are mounted in forks and can be swung round so as to resist running back. M.1375. 20,782, 21,528 L.S.

37. MODEL OF RECIPROCATING COAL-CUTTING MACHINE. (Scale 1 : 4.) Contributed by C. H. Waring, Esq., 1875.

This machine, patented by Mr. Waring in 1852, cuts a single chase in the working face of the coal, in either a vertical or inclined direction, by means of teeth or cutters attached to the front edge of a thin metal frame which, by a crank motion, is rapidly reciprocated on two circular guide rods attached to the machine, and provided with pointed extension screws by which they can be secured to the sides of the working. The frame holding the cutters is carried in slides on the frame that receives the reciprocating motion, and is advanced by feed screws that are automatically turned with each reciprocation. The machine is mounted on horizontal trunnions carried on a four-wheeled trolley, and is driven by one or two men working at a winch handle. There are two winch shafts so that the men may work either at the side or behind the machine. A weighted fly-wheel counterbalances the weight of the reciprocating frame, and also steadies the motion. M.1375. 20,775 L.S.

38. COAL-CUTTING MACHINE. Presented by Robert Ridley, Esq., 1864.

This machine, patented by Messrs. R. Ridley & J. G. Jones in 1863, was used with considerable success at the Ardsley Colliery, Leeds, and at the Newbottle Colliery, Sunderland. It is driven by compressed air, and swings horizontally a pick which undercuts the coal, while the machine is moved on rollers along the working face.

The machine consists of a metal frame, carried on four flanged wheels, which are geared together and rotated by a horizontal handwheel at the top, so as to travel it along while the undercutting is being performed. Within the frame is a horizontal cylinder fitted with a piston and trunk. By a connecting rod the piston rocks an arm attached to a vertical shaft, which is provided below with a socket that carries the pick. The air supply of the cylinder is distributed by a slide valve worked by a tappet motion. A second vertical shaft and pick socket are provided, so that the machine can be worked either right or left handed.

It is stated that this machine was capable of undercutting a seam of coal to the depth of 3 ft. and to the length of 150 yd. in eight hours. The air was supplied at a pressure of 50 lb. and delivered to the machine through india-rubber tubing 1·25 in. diameter. M.1395. 21,738 L.S.

39. BAR COAL CUTTER. Presented by Messrs. Mavor and Coulson, Ltd., 1906.

The bar type of mechanical coal cutter was tried as early as 1856 by Messrs. W. O. Johnston & J. Dixon, of Newcastle, who employed a revolving tapered bar provided with four helical grooves in which were inserted chilled cast-iron

cutting tools. The arrangement was subsequently developed by others, including the firm of Mr. W. T. Goolden, who were among the first to employ an electric motor for driving the cutter bar—a duty for which it is particularly suited owing to the speed of the bar being high.

The bar shown, which was patented by Messrs. F. W. Hurd and J. J. Millar in 1895, is tapered and has a square thread cut along it ; at the top and bottom of the thread, to suit the depth of chase to be cut, are tapered holes into which are inserted steel picks, the cutting portion of which is inclined to the shank at an obtuse angle. The thread acts as a conveyor in bringing out the cuttings, thereby preventing the coal from being so well supported by the fragments as to interfere with its being broken away from the top, in which case the work would have to be done over again by hand.

In addition to rotating, the bar receives an axial reciprocating motion of about 2 in. from two links actuated by eccentric pins in worm wheels, gearing with a worm on the driving pinion. The bar can be moved round in the horizontal plane by gearing, so as to cut its entrance into the coal face, and it can be used at either side ; it can also be tilted, to suit the dip of a seam or to avoid obstructions, and will work at different heights above the floor as required when the seam has a dirt-parting in it. The machine, and with it the bar, are advanced by a steel wire rope made fast to a distant point and wound on a drum operated by a worm on the motor shaft, gearing into a worm wheel driving an adjustable ratchet feed.

The bar shown is from the smallest size machine, which weighs 2,128 lb., while its bar weighs 168 lb. The depth of the under-cut is 2·5 to 3·5 ft., and the bar runs at from 300 to 500 revs. per minute ; it requires a motor of 12 brake H.P. usually supplied with continuous current at 400 volts. M.3259.

40. WIRE SAW FOR QUARRYING STONE. Presented by Sir C. Le Neve Foster, F.R.S., 1896.

This kind of saw has been successfully in use since about 1888 at marble quarries in Belgium and elsewhere, both for cutting blocks out of the solid, and also for cutting large blocks into smaller ones.

An endless wire rope of three strands is carried round pulleys which keep it pressed against the rock to be cut, and being fed with sand and water it abrades the material over which it is drawn. In cutting out of the solid it is generally necessary to sink two pits, one at each end of the cut ; the necessary pulleys are placed on a frame in the pits and lowered by a screw arrangement as the cut deepens. In marble the speed of the wires is 13 ft. per minute and the depth cut 3-4 in. per hour. Specimens of new and worn strands are shown. M.1583.

41. BORING AND WEDGING APPARATUS. Received 1872.

This apparatus, patented by Messrs. J. G. Jones and S. P. Bidder in 1868, was introduced as a substitute for explosives in coal mines ; it consists of a boring auger and of an arrangement of a hydraulic jack for forcing a wedge into the hole made by the former.

The auger has a three-pointed cutting bit, bores a hole 3 in. diameter and is 44 in. long over all ; it is rotated by a crank and gearing, and advanced by a feeding screw with a split nut which permits the screw to be withdrawn quickly. The whole apparatus is supported on a stand which is clamped by screws between roof and floor. The wedge is formed as a cylindrical plug, made up of two side pieces, which are forced into the hole together ; a central wedge is then placed in position between them by an attached handle, which is then screwed out and the central wedge forced home by a hydraulic jack that obtains its abutment from tail rods from the side pieces.

(*See* Trans. N.E. Inst. Min. Eng., xix., 11, 96.) M.2647. 21,739 L.S.

42. " MULTIPLE " WEDGE. Made by the Hardy Patent Pick Co., 1891.

This improved form of the " plug and feathers," for use in place of explosives, was originally patented in 1877 by Mr. G. W. Elliott. The two side feathers are placed in the hole, then the two side wedges, and finally the central wedge which is driven in by means of a sledge-hammer. Coal, previously undercut, is thus forced down. M.1588. 21,043 L.S.

43. MODEL OF MECHANICAL COAL GETTER. (Scale 1 : 8.)

This coal-getter was patented in 1883 by Messrs. W. F. Hall and W. Low, and used at the Haswell Colliery, Durham. It is a compound wedge, in which the central wedge is driven forwards by a double toggle joint. The two feathers are first placed in the hole, then the central wedge, and the rod connecting it with the toggle joints is placed in position. The toggles are screwed together by turning the handle, and so the wedge is forced between the feathers with increasing force. M.1589. 20,878 L.S

44. BURNETT'S COAL WEDGE. Presented by the Royal Commission on Accidents in Mines, 1886.

This is an example in wood of the wedge patented by Mr. C. Burnett in 1884-5. It consists essentially of rollers between the wedge and the feathers to replace sliding by rolling friction, and thereby increase the bursting action obtainable.

The feathers extend backwards and are connected by a collar that forms the sleeve for a nut, which is turned by a ratchet wheel and hand lever. In the nut is a long screwed rod that terminates in the wedge. Between the wedge and the feathers is a loose box holding four small rollers ; the nut, when turned, separates the feathers and so breaks down the coal.

(*See* Engineering, 1886, ii., 314.) M.2821. 21,043 L.S.

45. APPARATUS FOR BLASTING BY LIME. Made by Messrs. Cort & Paul.

The slaking of lime and its consequent increase in volume is utilised in this method, patented in 1881 by Messrs. C. S. Smith and T. Moore, for breaking down hard coal in which there are no fissures. It was introduced at Shipley Colliery, but is no longer used.

The cartridge is filled with compressed ground lime, and is 2·5 in. diameter by 4 in. long, with a longitudinal groove along it to accommodate a perforated iron pipe previously inserted in the hole, which would be about 2·75 in. diameter by 3 ft. deep. The cartridge is tamped in with at least 9 in. of clay. A tap on the outer end of the pipe is connected by a flexible pipe with the force pump shown. When the pipe is filled with water the tap is shut and the lime does its work in 10 to 40 minutes. The cartridges must be kept in the air-tight case shown.

An auger on a stand suitable for preparing the holes is shown ; it is a ratchet drill (*see* No. 13), but has a solid nut. The thread is square, 0·166 in. pitch ; the augers are 24 in. and 39 in. long by 3 in. diameter. M.1396.

46. DUMMY MINING EXPLOSIVES. Presented by Messrs. Nobels Explosives Co., Ltd., 1915.

Gunpowder has been largely displaced in mining and other excavation work, except where the material sought is required in large bulk, by explosives of the nitro-glycerine, nitro-cellulose (gun-cotton) and nitrate classes, which have a more shattering effect than has gunpowder. Nitro-glycerine is rendered comparatively safe to handle by being absorbed in some form of diatomaceous earth, when it is known as dynamite. There are numerous other mixtures made of the two first substances, with one another, or with the less active nitrate compounds, designed to secure either greater safety or defined effects, *e.g.*, blasting gelatine is mainly nitro-glycerine with a small proportion of nitro-cellulose ; gelignite contains more than half nitro-glycerine, nearly one-third of potassium nitrate, a few per cent. of nitro-cellulose, and the remainder wood-meal.

The following explosives are shown without wrappers :—(*a*) gelignite ; (*b*) samsonite ; (*c*) dynamite ; (*d*) gelatine dynamite ; (*e*) blasting gelatine ; (*f*) dynamite, frozen ; (*g*) blasting gelatine, frozen ; (*h*) gelignite, frozen.

The following are in cartridge wrappers :—(*a*) nobel carbonite ; (*b*) sunderite ; (*c*) gelatine dynamite ; (*d*) polarite ; (*e*) cambrite ; (*f*) dynamite ; (*g*) Glasgow dynamite, 40 per cent. ; (*h*) dynamite No. 4, 40 per cent. ; (*i*) samsonite ; (*k*) blasting gelatine ; (*l*) monobel No. 1 ; (*m*) dynobel ; (*n*) monobel powder ; (*o*) Ajax powder ; (*p*) Victor powder ; (*q*) Nobel ammonia powder ; (*r*) monobel powder ; (*s*) viking powder.

The cartridges are fired by a detonator attached to a safety fuse, of which several kinds are shown, which burns at the rate of about 3 ft. per minute, giving

sufficient time for the miner to retreat to a place of safety. When a large number of shots are to be fired simultaneously, a high tension spark and copper conductor are used to set off the detonator. Cartridges in section arranged for firing by each of these methods are shown. A box of detonators is shown separately.
Inv.1915-302 to 306.

47. PNEUMATIC FUSE IGNITER. Made by Mons. G. J. A. E. Bourdoncle, 1892.

This igniter is on the principle of the " fire syringe " which was invented as early as 1807. It has a cylinder with an air-tight piston working in it ; the fuse, together with a piece of German tinder, is introduced through the bottom end of the cylinder, a tight joint being made by an india-rubber washer. The piston is then pushed smartly home, so compressing the enclosed air that its temperature rises sufficiently to ignite the tinder, which in turn lights the fuse. A bell-shaped foot permits the igniter to be rested on a support while the piston is being pushed home, a side notch in its rim preventing damage to the fuse.
M.2635.

48. HEATH AND FROST'S LAMP. Presented by H.M. Home Office, 1901.

This is an oil lamp of the bonneted Mueseler type, embodying the shot-firing arrangement patented in 1886 by Messrs. J. Heath and W. Frost. The safety fuse is inserted through the base into a tube extending into a gauze-protected space at the top ; a pricker can be passed through the tube to pierce the fuse by forcing up a spring shield, and after being made red hot in the flame can be withdrawn, so igniting the fuse. It has a screw lock, and weighs 3·5 lb.
M.3154.

49. PERCUSSION IGNITER. Made by Trevis Holmes, Esq., 1892.

In this appliance, patented in 1891 by Mr. Holmes, the end of the fuse is held in a tube containing a chamber in which is a percussion cap on a nipple. A pin which passes out of the chamber above the cap is struck by a hammer when the fuse is to be fired. A later and more convenient form of this igniter is mounted like a pistol with a percussion lock. M.2634.

50. ELECTRIC IGNITER. Made by W. Ladd, Esq., 1893.

This is a small magneto-electric machine for firing shots in mines. Four bobbins, wound with copper wire and mounted on a frame, are rotated by gearing between the poles of two compound permanent horseshoe magnets. Terminal screws are provided for the attachment of wires leading to the charge ; the push-button enables the circuit to be closed at any desired moment. M.2650.

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51. APPARATUS FOR TESTING MINING EXPLOSIVES. (Scale 1 : 24.) Presented by H.M. Home Office, 1901.

A Government Committee having been appointed to determine the suitability of various explosives for use in mines, the plant represented was erected at Woolwich in 1897 for carrying out experiments by firing charges of each explosive into mixtures of air and gas, or of air and coal dust.

The plant for testing in a mixture of air and gas consists of a cannon mounted on rails and arranged to discharge into a long metal cylinder which contains an explosive atmosphere, prepared by introducing a definite volume of coal gas from a gas holder and then mixing this with the air in the chamber and pipes by a centrifugal fan, arranged in the circuit and driven by a gas engine. Suitable valves are introduced for controlling the various operations, and the explosion chamber is fitted with external flap valves and is closed at one end by a paper diaphragm, beyond which is a tuft of gun-cotton to indicate definitely if the mixed atmosphere has exploded. The cannon in which the blasting charge is fired, having to resist a pressure of possibly 100 tons per sq. in., is wire-wound

and has a removable liner, as it was found that the inner tube required renewal after 200 charges had been fired. The observers are protected against any failure of the cannon, by a concrete shield at the side, and the firing is done electrically.

The charges used are equivalent to 6 oz. of gunpowder, or 2 oz. of dynamite, and the cannon is stemmed with 6 in. of dry clay ; it was decided that an explosive was not suitable for use in mines if 40 charges of it fired in this way, successively, into an explosive atmosphere caused more than two ignitions of the gaseous mixture. All explosives are too dangerous to be fired without stemming, so that the dry-clay stemming adopted is the least favourable practical condition ; it was moreover found that the explosive atmosphere prepared was as dangerous as any possible in a mine, and more so than one of coal dust and air, while the action of the cannon represents that of a blown-out shot and was, therefore, particularly likely to fire the artificial mine gas.

The plant for testing the action of explosives in an atmosphere charged with coal dust consists of a vertical cylinder secured to a bed of concrete, in the centre of which is placed a vertical cannon, identical in construction with that in the other apparatus. The dust-laden atmosphere is blown into the base of the cylinder by a centrifugal fan, upon the delivery pipe of which is fixed a closed hopper containing coal dust. When the fan is driven by the gas engine, the air delivered into the cylinder carries with it a large amount of this coal dust, thus creating an exceedingly dense atmosphere which, however, although distinctly explosive, was found to be far less so than the explosive gaseous mixture used in the other apparatus. M.3145.

MINE TIMBERING AND OTHER SUPPORTS FOR EXCAVATIONS.

52. MODEL OF PROSPECTOR'S SHAFT. (Scale 1 : 12.) Made in the Museum, 1916. Plate I., No. 4.

This represents the shaft timbering employed for the preliminary exploration of metalliferous deposits in the Australian Continent.

Prospectors are usually practical miners and show considerable ingenuity and economy in their methods of timbering under difficult local conditions. The shafts are usually small, and are sunk where the prospector finds a good " prospect " or at a point where he anticipates " striking " ore at a comparatively short depth from the surface. They are seldom used for deep exploration work, but are often utilised afterwards in connecting up the main workings of a mine, for ventilation, for lowering waste rock, and for filling up ore chambers, etc.

Logs are placed on each other from the surface, to a height of 6 ft. or more, for the purpose of " dumping " the waste rock and ore won in the process of sinking the shaft. Erected on the logs is a windlass with a winding barrel carrying a rope 0·75 in. diameter with a raw hide bucket. A piece of green hide fixed to the top bar and wound once round the barrel acts as a brake, and there is a sliding-bar catch. The shaft hoisting way is 5·25 ft. by 3·5 ft. ; and the ladder way 2·5 ft. by 3·5 ft. The strip of canvas or hessian between the two compartments is for ventilation purposes. The logs vary from 7 to 9 in. diameter, those for the sides being 8 ft. 7 in. long and the end logs 4 ft. 6 in. To level up, the wide ends are placed against the narrow ends. The sides are lagged with poles 3 to 4 in. diameter. The timber sets are 6 ft. apart, with logs 5 to 6 in. diameter and 5 ft. and 8 ft. long. Ladders are placed vertically and fixed to the sets of timber.

A rough bough or canvas shelter is erected over the shaft as a protection from the sun. On the posts hang the " billy " can and water bag usually carried by prospectors. Inv. 1916—11, S.M.775.

53. MODEL OF TIMBER DRUM FOR SHAFT SINKING. (Scale 1 : 12.) Made by Herr Carl Schumann.

This is a method of timbering, of limited application, used in sinking through loose water-bearing ground, *e.g.* alluvial gold gravels and sands. The method is an adaptation to shaft sinking of the " spilling " or " forepoling " method used in driving in loose wet ground.

Frames (" curbs " or " cribs ") composed of two thicknesses of segments cut from planking, breaking joint and fixed together with wooden pegs, are placed from 1 to 3 ft. apart according to the nature of the ground to be

traversed, and a close lining of planks is nailed outside them, the edges of the planks being planed to insure good joints; a similar lining is nailed to the inside of the curbs in the lower part of the drum. The ground inside is excavated and the drum sinks by its own weight until it reaches a more solid and impervious stratum. Sometimes the lower edge of the drum is shod with iron as shown. M.2802. 20,781 L.S.

54. MODELS OF CORNISH TIMBERING FOR A RECTANGULAR SHAFT. (Scale 1 : 12.) Received 1883.

The frames are composed of two side-pieces halved at each end and resting upon two end-pieces, also halved; these frames are placed from 2 to 4 ft. apart the distance being maintained by small props. A lagging of planks is placed behind the frames to keep loose material out of the shaft. In loose ground the side pressure is sufficient to grip and support the timbering, but in harder ground the frames are supported where necessary by putting in bearers, which project about 2 ft. into holes cut in each side of the shaft. In hard rock frames are often dispensed with, cross-pieces wedged against the sides being used where necessary to hold the guides.

In the first model a compartment that serves for winding the ore is cut off by means of a closed partition nailed to cross-pieces. One portion of the remaining space serves for the pump-rods and pipes; in the other part are fixed the climbing ladders, at an angle of 6 deg., resting on platforms at every 20 ft. By arranging the ladders parallel to one another they could have been placed at a much more convenient angle than that here shown.

In very loose ground it is necessary to sling the frames from one another, and from bearers at the surface or in firm ground, by means of two bolts through each end-piece, as shown in the second model. M.2792—3. 20,813 L.S.

55. MODEL OF SHAFT TIMBERING USED IN SAXONY. (Scale 1 : 16.)

The model shows a small shaft 8 ft. by 6·3 ft., which might be a prospecting shaft or an underground sinking from a level.

Round timber is used, otherwise the system of support is similar to that in vogue in Cornwall and elsewhere. Bearers are put under the end pieces of alternate frames and the intermediate frames are supported from those immediately below, each by six studdles. The shaft is divided into two compartments, one for a ladder-way and the other for raising the ore in buckets. The passage of the latter up the shaft, which is often an inclined one, is facilitated by fixing planks on the foot-wall side. M.2804. 20,791 L.S.

56. MODEL OF BRICKWORK LINING FOR A SHAFT, AS USED IN SAXONY. (Scale 1 : 16.)

While sinking, the shaft is supported at intervals by wooden "curbs" with a backing of laths; brickwork is afterwards built in between the curbs.

The curbs are made of segments of planking pegged together, with iron clamps across the joints. The topmost curb is stronger than those below, and would be firmly supported by a ledge of ground or rock left under it. The curbs are supported temporarily on beams slung by iron rods from the stronger curb above, the spaces between the curbs are bricked in one after another, downwards. The curbs may be left in, but it is more usual, as in the model of La Grange shaft (*see* No. 62), to put in a brick lining throughout the shaft, the wooden supports being taken out and replaced by brickwork or, if this cannot be done, the permanent lining is carried up within the woodwork. M.2801. 20,794 L.S.

57. MODEL OF SHAFT TIMBERING USED IN AUSTRALIA. (Scale 1 : 6.)

There is a continuous lining of thick planks, similar in many respects to that in use in the Scotch coal-fields. The side-pieces bear on the ends of the end-pieces, and the end-pieces are prevented from being thrust inward by pegs fixed in the side-pieces. The shaft is divided into two parts by planks cut long so that they may wedge into position and act as struts; they are kept from slipping sideways by boards nailed up each side. M.2810. 20,806 L.S.

58. MODEL OF SHAFT TIMBERING USED IN THE HARZ. (Scale 1 : 16.) Received 1859.

The model represents an inclined shaft 30 ft. long by 10 ft. wide following the course of a lode. Rectangular sets of round timber, 12 in. diameter, are first put in; the joint between the end and side-pieces has bearing faces slightly tapering downwards, the end-pieces with slightly bevelled ends being wedged between. The sets are kept 3·3 ft. apart by struts.

The sets are assisted in supporting the hanging-wall by three frames within them, one at each end and one at the middle in vertical planes at right angles to the hanging-wall. When putting in one of these, a bearer 24 in. diameter is firmly fixed by hitching it in the foot-wall and wedging it against the hanging-wall. Two long pieces 19 in. diameter, are placed on this bearer and kept apart by struts of timber 16 in. diameter, which are put in, beginning at the bottom, by cutting a socket on the foot-wall piece for one end of the first strut and hollowing its other end for wedging against the hanging-wall piece. The remaining struts are hollowed at both ends and are wedged in one after the other, each strut at one end touching the one below and at the other end being itself touched by the one above.

The shaft is divided by the middle frame into two parts, one being used for winding ore and the other for a ladder-way, pumps and often a man engine.

M.2800. 20,804 L.S.

59. MODEL OF SHAFT TIMBERING ON THE COMSTOCK. (Scale 1 : 12.) Received 1883.

This timbering was first used on the Comstock lode, Nevada, U.S.A.

Square timber of uniform size is used for the frames, and all the joints are carefully made; the side-pieces of the frames are halved and rest on the end pieces. Three partition timbers notched into them serve to support the wooden guides of the cages in the three winding compartments; the fourth compartment is used for pumping. Between each two sets there are ten posts, of which those at the four corners are of extra size; the ends of the posts are notched in and the lining is completed by a close sheathing of planks. M.2795. 20,788 L.S.

60. MODEL OF SHAFT-SINKING ARRANGEMENTS. (Scale 1 : 10.) Made by Mons. P. Regnard. Received 1899.

This shows a method of sinking a shaft through loose water-bearing strata. A pit of the usual rectangular form is excavated, and timbered with sets, studdles and plank lagging. A circular wooden curb (in this case provided with a cutting shoe) is placed on a level bed at the bottom of the excavation and brick walling built upon it to a height of from 3 to 6 ft., then another curb is laid, and so on. This weight, or an added load, causes the shoe to sink as the interior earth is excavated. The curbs are tied to each other and to the cutting shoe by through bolts, which are left in the brickwork. A close lagging of planks, or a mantle of sheet iron as in this model, is fixed outside the curbs to facilitate descent and prevent disturbance of the brickwork. M.3044. 19,771 L.S.

61. MODEL OF CAST-IRON TUBBING. (Scale 1 : 12.) Contributed by Messrs. Thornewill & Warham, 1859.

Such tubbing is generally used in this country for water-bearing strata. As in La Grange shaft (*see* No. 62), the segments are built upon a foundation of wedging curbs; the plates, however, are not bolted together, and the strengthening flanges, ribs, and brackets are turned towards the rock. A joint is made by strips of soft wood placed so that the grain lies radially with regard to the shaft, wedges being afterwards driven into this to make the joint quite staunch; two adjacent sides of each segment are provided with secondary flanges which overlap the joints and keep the wooden strips in position. A hole in the middle of each segment allows water to escape from the back while the plates are being laid, but is afterwards plugged simultaneously with the wedging of the joint.

M.2788. 20,805 L.S.

62. MODEL OF CAST-IRON TUBBING AND DETAILS OF SHAFT AND CAGE. (Scale 1 : 5.) Received 1893. Plate I., No. 5

This is a model of La Grange shaft, Mines d'Anzin, France, which was sunk through water-bearing strata of Tertiary and upper Cretaceous age down to the coal measures below, which were, however, dry owing to a watertight bed at

the bottom of the chalk marl. The tubbing was carried down to the watertight bed above the coal where a joint was made, so saving a heavy constant charge for pumping. The sections of the strata on the sides of the shaft have been modelled and painted to represent the actual rock.

The lower part of the lining is of ordinary shaft brickwork, and above it are laid two oak curbs which support two strong cast-iron wedging curbs bolted together in segments ; these curbs form the base upon which the tubbing is built up. The watertight joint between them and the marl is made by a packing of moss and planks driven tight with pointed wedges.

The tubbing is formed of cast-iron segments bolted together and breaking joint vertically ; the joints are made with sheet lead. Across the centre of the shaft are steel girders, resting on lugs cast on the tubbing, which serve to support the steel guides for the two cages. There are four guides, supported by clamps which rest on the cross girders, a full size detail of which is shown adjacent. In addition, there are four vertical wooden rails to receive the grip of the safety catches. A close casing of boards or " brattice " on the left-hand side cuts off a segment of the shaft which is used for ventilation, while a similar space on the right is used as a ladder-way and is provided with wooden ladders and platforms at intervals.

The cages have two decks, each of which carries four wagons ; safety catches worked by springs are provided so that if the rope should break the catches immediately grip the wooden guides and retain the cage. Disconnecting hooks are also employed, which in case of overwinding will release the winding rope, but support the cage at the pit-head frame. Flat winding ropes of aloe fibre are used. M.2522. 21,069 L.S.

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63. MODEL OF AUSTRALIAN " SPACED-BOX " MINE SHAFT. (Scale 1 : 12.) Made in the Museum, 1916.

This model represents the " box " method of shaft timbering used in Australia. In some mines the timbers are fitted closely together and form a continuous box ; in other cases the timbers are separated by " chocks " nailed between each timber set. A safer method is, as shown by the model, to form the raising chock of solid timber whereby the danger of a falling chock is obviated. This is known as the spaced method, and has advantages over the closed box, as it permits of a certain amount of play in the timbers in expanding ground. There is also considerable saving in the quantity of timber required. The method is of course, inapplicable when the ground is bad, sandy, or of loose character.

The shaft shown is for a pump and ladder way 4 ft. by 4·5 ft., and two hoisting ways, 3 ft. by 4·5 ft. The timber is karri (*Eucalyptus diversicolor*). The wall plate is 12 ft. 5 in. long by 9 in. by 6 in. The bearers are of the same scantling, 6 ft. 6 in. long. The spaced box timbering is of 9 in. by 2 in., while the bratticing (division boarding) is 9 in. by 2·5 in. with 0·75 in. tenon. These timbers are spaced apart 3 in. The guides in the hoisting ways are 4 in. square except the end guide which is 5 in. by 4 in. These are fastened by coach screws 0·875 in. diameter except where they cross the frame. Here they are let in 1 in. deep into a slot dovetailed at the sides and held by corresponding wedges 18 in. long tapering from 2·5 to 1 in. Ladders are of 4 in. by 2·5 in. timber 12 in. wide, rungs of 0·625 in. round iron every 10 in. apart, and every fourth rung bolted through. Inv. 1916—333. S.M.842 L.S.

64. MODEL OF RAND SHAFT TIMBERING. (Scale 1:12.) Made to order from drawings prepared in the Museum, 1915. Plate I., No. 6.

On the Witwatersrand Goldfields, owing to favourable geological conditions, close methods of shaft timbering are not required. The size of the shaft and the scantling of the timber employed varies in accordance with the position of a shaft relative to the outcrop.

The shafts can be classified roughly as follows :—(*a*) Those on the outcrop which have three compartments and vary from 700 to 1,000 ft. deep. (*b*) Those intermediate between the outcrop and the deep level which have four compartments and are from 1,500 to 3,000 ft. deep. (*c*) Those on the deep level which have four hauling ways and one combined ladder and pump compartment. The shafts are 4,500 to 5,000 ft. deep. The last named is the one shown in the model.

The temperature increase is only 1 deg. F. for every 220 ft. in depth approximately, so that, with modern methods of ventilation and hoisting it is probable that depths of 8,000 to 9,000 ft. will be attained. In such a case the shafts would have six hoisting ways and one combined ladder and pump way.

In the model shown the four hauling ways are 6 ft. wide by 5 ft. long, while the ladder and pump compartment is the same width, but 6·5 ft. long. The timber is karri and oregon pine as shown. The top bearer sets are 30·33 ft. long, and the end pieces 10·5 ft. long, both 9 in. by 10 in. section. Four intermediate bearer sets are 10·5 ft. long by 10 in. by 7 in. The studdles are 4·33 ft. long, by 12 in. by 4 in. The corner posts are the same length and 8 in. sq. The distance apart of these bearers varies according to the character of the ground. The bearer sets rest in recesses cut for them and support the intermediate sets by hook bolts with fly nuts.

The dimensions of these intermediate sets are as follows:—Wall plates, 30·33 ft. long by 9 in. sq.; dividers, 6·25 ft. long by 7 in. by 10 in.; corner posts, 5·16 ft. long by 8 in. sq.; studdles of the same length by 12 in. by 4 in.; guides, 6 in. by 4 in.; bolt plates over guide joints, 12 in. by 7 in. by 0·375 in. thick; guide bolts, 0·625 in. diameter divider bolts, 0·5 in. diameter. The hanging bolts are 1·25 in. diameter by 7 ft. long. The ladders are 30 ft. long with rungs of 0·625 in. round iron 10 in. apart, every fifth rung being bolted through. The angle of these ladders is 8 deg. and the "sollars" to support them are at every 30 ft. "Bratticing" between the ladder way and the first compartment, and between the second and third hoisting ways is of 9 by 1 in. timber. The pump and compressed air pipes and the electric cable are shown.

The bottom portion of the model illustrates the method of sinking. The rock is cut in a series of steps by drilling sets of holes whose position and angle are seen in section. The centre row of holes is fired first and the side rows last. Access to the working place is obtained by a suspended chain ladder.

Inv. 1915—557. S.M.768 & 776.

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65. MODELS OF LEVEL TIMBERING USED IN THE HARZ (Scale 1 : 16.) Received 1859.

The first model shows methods used where the level is driven along a vein in which one or both walls form convenient sides to the level and need but little support. When not vertical the overhanging side of the vein is known as the "hanging-wall" and the other side as the "foot-wall." The timber cross-piece is footed in a hitch, either in the foot-wall itself or in a piece of timber lying against the foot-wall, while the other end is wedged against the hanging-wall or a piece of timber lying against it; in the latter case it is generally hollowed to fit the timber. The cross-piece is not at right angles to the hanging-wall, as by cutting it a little too long and putting it in from above it sets more securely. The first model illustrates several cases:—

(*a*) In this, the simplest case, the cross-piece or stretcher is hitched directly to the foot-wall and wedged against the hanging-wall. This method may be used either to support the latter when it tends to break away in large pieces or, when both walls are strong, several stretchers with planks or poles placed above serve to support rubbish it is desirable to leave underground.

(*b*) Here the hanging-wall is weak, so that the stretcher is wedged against a side-piece under the former, as well as being hitched in the foot-wall as usual.

(*c*) Here the foot-wall is weak, so that there is a side-piece against it into which the lower end of the stretcher is fixed, while its other end is wedged directly against the hanging-wall. The side-piece is kept out slightly by distance pieces at top and bottom so that the ends of the poles can pass between the piece and the foot-wall.

In the remaining cases side-pieces are used against both foot and hanging-walls, in (*e*) and (*h*) there are distance pieces as in (*c*) and also a plank placed between a side-piece and the wall; the planks support the inner end upon one set of poles while the side-piece itself supports the outer ends of the next set in front.

(*g*) In this case the hanging-wall end of the stretcher is not hollowed, but the front of the piece against the hanging-wall is flattened and a board introduced between it and the stretchers; the method of using poles for keeping the rubbish out of the level is also shown.

The second model illustrates three methods employed where the section of the level is trapezoidal.

(*a*) Here one side of the level is strong, so that a recess, cut in the upper part of it, is sufficient to support one end of the cap; the other end of the cap is supported on a post. For the joint, the top of the post is made horizontal and the cap bevelled to fit it.

(*b*) This illustrates complete frames composed of caps, posts, and transverse soles.

(*c*) This illustrates complete frames with longitudinal soles. Two methods of casing are shown : in one the slabs from the squaring of large balks of timber are placed on top of the caps and behind the posts, in the other pointed poles are driven forward. These poles are of sufficient length to extend over three frames ; in the sides they are arranged as in the last model, but in the roof the back-end as well as the middle is supported on a plank by small filling pieces, so that the ends of the next forward poles can pass between it and the cap.

The lettering in these models is in the opposite direction to that in which the level would be driven. M.2798—9. 20,796 L.S.

66. MODEL OF DOUBLE TIMBERING USED IN SAXONY. (Scale 1 : 16.) Received 1865.

The section of the level being rectangular, casing planks can be driven ahead of the frames, to serve as an advance shield in bad ground.

Double and single frames are put in alternately, so that a particular plank in the roof goes over the small inner part of a double frame, over the intermediate single frame, and finally over the outer part of the next double frame. Three sizes of frames are necessary : the largest 9 ft. high and 5·5 ft. wide, the smallest 8·25 ft. high and 4 ft. wide, while the intermediate frame is 8·5 ft. high by 4·5 ft. wide. The double frames are placed 6 ft. apart with the single frames midway between. The joints are made by halving the ends of the cross-pieces and notching the tops of the posts. The casing planks are fixed firmly in position by wooden wedges.

Space for a water course is left by supporting the wagon-way about 15 in. above the floor on cross-pieces let into the posts. M.2803. 20,798 L.S.

67. MODEL OF TIMBERING USED IN THE FURNESS DISTRICT. (Scale 1 : 12.) Received 1859.

In the hæmatite iron mines of Furness, Lancashire and of Cumberland, the ore occurs in "pockets" and is worked downwards in slices some 9 ft. thick. The roof is composed of boulder clay, and is continually settling down as the timber is insufficient for its complete support, but as it only comes down gradually it forms a safe roof to work under. Unbarked larch is the timber chiefly used ; after a working is abandoned, the timber is taken out as far as possible and used elsewhere.

The small shaft from which the straight level proceeds is a "rise," put up from the main level below ; it is about 6 ft. by 4·5 ft. in plan and lined generally with 6 or 7 in. roughly squared Norway timber, each piece being halved at its ends to make the joint. Four pieces go to a set and the sets rest on each other. The rise is divided into two compartments : one serves as a passage for the ore into the main level below, and is closed at the bottom by a slide so that the ore can be run as required into a wagon and taken to the shaft ; the other compartment serves for ventilation and as a ladder-way. The frames are composed of two inclined side-pieces "collared" at the top to receive the round cap or head-tree. To prevent side pressure from forcing the props inwards, dowels 1 in. in diameter are inserted in the head-trees. The frames are placed about 2·3 ft. apart, and until they get the "weight" from above are kept in place by means of "spiles"—small planks 4·5 ft. long and 1·5 in. thick. Another use of spiles is to form an advance shield to protect the men who are working in the "fore-breast," the small planks pass under the last but one and over the last head-tree. The settling down of the roof bends the spiles into the position in which they are shown in the model. The small branch level shows the spiles simply placed above the head-trees. The model shows the wheelbarrow formerly used, but now replaced by wagons running on steel rails. M.2809. 20,797 L.S.

68. MODELS OF CORNISH METHODS OF TIMBERING LEVELS. (Scale 1 : 12.) Received 1883.

In the first model the frames are composed of a horizontal cap rebated at both ends to receive the tops of two inclined side posts ; the rebates prevent the posts being forced inwards by side pressure. The frames are placed at a distance of 1 to 3 ft. apart, and when necessary a sheathing of laths is placed behind them. The model shows a close casing, but this is not always necessary, it being often sufficient to place a few laths behind the posts and in the roof.

In the second model the only difference is that the side posts are vertical instead of inclined. M.2794. 20,799 L.S.

69. MODELS OF MASONRY SUPPORTS IN LEVELS, USED IN THE SAXON MINES. (Scale 1 : 16.)

The first model shows a level driven along a vein where the hanging-wall is sound and needs no support; an arch is built on the foot-wall side from the floor to the hanging-wall.

The second shows a small gallery with sides in hard rock; the roof is supported by a segmental stone arch.

The third shows a portion of a large adit level or water gallery, the upper part of which, constituting the wagon-way, is supported by an arch of masonry; the water is carried by a deep channel cut in the solid rock. In all three cases the arch stones are made of the gneiss of the district dressed to shape and set in cement. M.2805—6 & 2808. 20,807 L.S.

70. MODEL OF COMPOSITE LEVEL SUPPORTS. (Scale 1 : 8.) Made by Herr Carl Schumann, 1880.

This illustrates a case in which one end of girder or piece of old rail is supported on masonry and the other end on a timber post, with a notch on the inside of its upper end, against which rests a piece of iron riveted to the cap and intended to prevent the side-piece being thrust inwards. On the top of the post is placed a piece of iron plate to form a bed for the cap.

M.2814. 20,795 L.S.

71. MODEL OF LEVEL WITH METAL SUPPORTS. (Scale 1 : 8.) Made by Herr Carl Schumann, 1880.

This shows a case where a wide level, as at a shaft bottom, is supported by steel girders and hollow cast-iron columns with flanges at both ends resting on transverse soles. The cross-pieces support steel joists running in the direction of the level. Wooden lagging in the roof is added, and wooden slabs are placed behind the posts to prevent the sides coming in. The floor is laid with flat plates which allow of the wagons being readily turned in a small space, or placed on the return line. M.2811. 20,687 L.S.

72. MODELS OF METAL SUPPORTS FOR LEVELS, USED IN SAXONY. (Scale 1 : 8.) Made by Herr Carl Schumann, 1880.

The first model shows a case where one side of the level is strong and the other weak; on the strong side the girder rests in a recess cut in the rock, and in the other is supported by a prop of the same section as itself. To prevent the posts being forced inwards, small pieces of iron are riveted to the underside of the cap near the two ends. The props rest on small plates of iron on transverse wooden soles. A lagging is placed between the girders, the arched platform thus made supporting the rubbish left after the removal of the ore by "stoping." Similar lagging is placed between the posts.

In the second model the level has strong sides, but the roof is supported by arched metal rails springing from the sides and resting on end bearer plates.

The third model is an example of a narrow level for a single wagon road with both sides supported by metal rails.

The fourth model only differs from the last in being wider for a double wagon road. M.2812—3 & 2816. 20,792 L.S.

73. MODELS OF LEVELS SUPPORTED BY CURVED IRON FRAMES. (Scale 1 : 8.) Made by Herr Carl Schumann, 1880.

The material is brought underground in a bent form, a whole frame being formed of one length of iron. The frames are footed in iron shoes fixed at the correct angle in a transverse wooden sole.

The first model shows a narrow level, and the second a wide one for a double wagon-road, supported by curved rails in iron or steel, and lagged with round timber. In the wide level an iron prop is added under the centre of the frame.

This series of models shows how when first used metal supports were applied in the same way as those of wood. Metal frames may, however, be made of any shape or curvature and with adequate strength at the joints, so that a more economical distribution of materials is obtainable than is possible with wood.

M.2815. 20,688 L.S.

74. MODELS OF COMSTOCK LEVEL TIMBERING. (Scale 1 : 12.) Received 1883.

These show a special system of level timbering first used in the Sutro tunnel on the Comstock lode where the ground was loose and swelling, and heavy pressures on all sides had to be resisted.

In the first case the framing is trapezoidal, as in Cornish practice (*see* No. 68), but with the addition of transverse sole pieces rebated to take the posts. In the second case the cross section of the level is modified to an irregular hexagon ; in both cases the frames are made of heavy timber, often 12 in. sq., jointed in a special manner and lagged continuously on roof, floor and sides with planks closely set together. Wagon-ways are also shown. M.2796. 20,793 L.S.

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75. MODEL OF WATER-TIGHT CLOSURE FOR A LEVEL. (Scale 1 : 12.) Made by Herr Carl Schumann.

This illustrates a method used in Saxony about 1840 of so closing a level as to prevent the entrance of water even under very considerable pressure ; such a form of dam can only be erected where the strata are sound.

The work is commenced by hewing a recess in the walls of the level, so as to form a skewback or abutment for a domed arch with its convex face towards the water. This dome is built of carefully shaped wooden blocks, laid dry with the joints closed by wedges, first of wood and finally of iron. While the dome is being built a hole is left near the bottom to prevent water accumulating till the dome is completed ; near the centre a manhole 21 in. diameter is provided which can be closed by a leather or rubber-jointed cover. M.2807.

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76. MODEL OF NEWHOUSE ADIT LEVEL. (Scale 1 : 12.) Presented by Sir C. Le Neve Foster, F.R.S., 1896.

This tunnel, situated at Idaho Springs, Colorado, U.S.A., was undertaken in 1895 to undermine at an average depth of 2,000 ft., a mountain of mica, schist and gneiss traversed by gold and silver bearing veins.

The tunnel is 10 ft. wide by 9 ft. high, and has a gradient of 1 in 240. It carries a double line of rails, 18 in. gauge, with a space of 30 in. between. Beneath them is a wooden drain, 2 ft. wide by 14 in. deep, the top of which serves as a footway. As however but little water was met with, this drain was utilised for ventilation by connecting it with a fan at the mouth of the adit. Dynamite was the explosive used, and at intervals of about 100 ft. short crosscuts were driven to serve as shelters for the men when blasting.

The timbering represented was only required for the first 80 ft., as after that distance the rock was sufficiently sound to render it unnecessary. The frames are of 9 in. square timber, and are placed at 5 ft. centres with intermediate struts and an outer covering of planks. In shape they resemble the irregular hexagon adopted in the Sutro tunnel (*see* No. 74). M.2941.

77. MODEL OF MAIN ADIT OR LEVEL TIMBERING. (Scale 1 : 12.) Made in the Museum, 1915.

This model illustrates timbering sets as used in main adits, levels, drifts and tunnels.

The construction of such timber sets is usually applied where the mine workings become a permanent way for the haulage and transport of ore and mine material from other stopes and levels to and from the surface.

The size or diameter of the timber used is naturally dependent to a very great extent upon the character of the ground, and sometimes varies considerably in short distances, but this example may be taken as a fairly typical one under average conditions of the five-piece sawn timber set of three posts, cap, and sill or footplate.

The dimensions are :—Posts, 7 ft. 2 in. by 8 in. by 9 in. ; cap, 11 ft. 6 in. by 8 in. by 9 in. ; sill, 12 ft. 3 in. by 6 in. by 9 in. ; all tenons, 1 in. ; top lagging, 8 in. by 2 in., spaced 2 in. ; side lagging, 8 in. by 2 in., with 4 in. spacing chocks. The framed sets are 4 ft. apart. Height, 7 ft. inside clear of the timbers.

Inv. 1915—426. S.M.738 L.S.

78. MODEL OF FOUR-PIECE LEVEL SET TIMBERING. (Scale 1 : 12.) Made in the Museum, 1915.

This model illustrates the ordinary level set mine timbering, showing posts, cap piece, and foot sill of sawn timber; this method is also used in tunnel timbering, and known as "battered set."

The lagging is of 8 in. by 2 in., with 3 in. "chocks" between. Posts and caps are 8 in. by 8 in., sill piece, 6 in. by 8 in. Inside dimensions of the sets are at the top 4 ft. 6 in., height, 6 ft. 6 in., bottom, 5 ft. The space between the lagging and slate rock is filled in with waste rock.

Inv. 1915—382. S.M.713 L.S.

79. MODEL OF FOUR-PIECE LEVEL SET FOR SIDE PRESSURE. (Scale 1 : 12.) Made in the Museum, 1915.

This model represents special joints and framing of the timbers for side pressure and swelling ground.

By this method, the full strength of the timbers is obtained with very little tendency to slip or split, and the pressure up to the point of crushing serves to bind the set together.

Dimensions:—Posts, 7 ft. 9 in. by 8 in. by 8 in.; cap, 5 ft. 4 in. by 8 in. by 8 in.; sill, 5 ft. 5 in. by 8 in. by 8 in.; lagging, 8 in. by 2 in.; inside dimensions of the sets, 5 ft. by 6 ft. 6 in. The framed sets are placed 4 ft. apart. Heavier timbers are used where the pressure is very great.

Inv. 1915—427. S.M.737 L.S.

80. MODEL OF "PENNING" METHOD OF TIMBERING. (Scale 1 : 12.) Made in the Museum, 1916.

This represents timbering used to support flat and irregular inclined veins and ore deposits.

It is an application of the "crib" method used in stratified ore deposits, and is built up of logs from the foot-wall of the ore deposit to the hanging-wall. The longer pieces of timber, known as "tie logs," are used to tie the cribs together. They also form caps and sills for the drift or passage way.

This arrangement is very strong but requires a large quantity of timber. Where the pressure is very great the cribs are further reinforced by filling them with waste rock, as shown in one instance.

The dimensions are:—Passage way, 7 ft. 3 in. by 6 ft.; height of the cribs, 12 ft. 6 in.; logs, 6 ft. 6 in. by 9 in. diam.; tie logs, 21 ft. by 8 to 9 in. diam.

Inv. 1916—3. S.M.758 L.S.

81. MODEL OF STULL TIMBERING, ANGLE SETTING. (Scale 1 : 12.) Made in the Museum, 1916.

The stull method of timbering is the application of the post used in flat ore deposits to the conditions of inclined veins. Stulls are used almost universally in the smaller ore-deposits and veins of an inclined character.

If the stull were placed at right-angles to the hanging-wall any movement of the latter would probably cause the stull to fall. It is therefore placed at an inclination of underlie approximating to a certain fraction—about one-fourth—of the angle of dip of the ore deposit or vein. In the model the vein dips at an angle of 32 deg. and the stull is therefore set at an underlie of 8 deg. from a right-angle to the wall.

The dimensions of the timbers are 6 ft. by 12 in. diam., with head-boards 3 ft. by 1 ft. by 3 in. Inv. 1916—12. S.M.773 L.S.

82. MODEL OF STULL TIMBERING WITH VARYING ANGLES OF WALLS. (Scale 1 : 12.) Made in the Museum, 1916.

This represents one of the methods adopted in supporting ore-deposits or veins where the walls are irregular and inclined at varying angles.

This example represents a section of a "saddle-reef" (or arch-like formation) of quartz that occurs conformable to the lower silurian slates and sand-stones on the goldfields of Bendigo, Victoria. Only the west "leg" is shown here.

The east "leg" usually dips with the strata approximately at the same angle as the "west leg," but in the opposite direction.

Dimensions :—Drift or level, 5 ft. 3 in. to 6 ft. ; stulls, 5 ft. to 6 ft. by 1 ft. diameter ; head plate, 2 ft. by 1 ft. by 3 in. ; longitudinally the sets are 4 ft. apart, while transversely the spacing varies from 2 to 3 ft. at the bottom and 4 to 6 ft. at the top. Inv. 1916—13. S.M.774 L.S.

83. MODEL OF THREE-PIECE STULL TIMBERING. (Scale 1 : 12.) Made in the Museum, 1915.

This model is an example of a three-piece stull set in timbering a mine level.

If both walls of the ore deposit are weak, or the vein is of considerable width, one post is placed on the hanging-wall and one nearly halfway along the stull, and the intervening space and foot-wall filled with waste.

The dimensions are :—Hanging-wall post, 12 ft. by 9 in. diam. ; stull, 11 ft. by 9 in. diam. ; centre post, 5 ft. by 6 in. ; lagging, 3 to 4 in. ; 18 in. gauge rails ; sleepers, 2 ft. 6 in. by 6 in. by 4 in. Inv. 1915—428. S.M.741 L.S.

84. MODEL OF STULL AND FALSE STULL. (Scale 1 : 12.) Made in the Museum, 1916.

Should the foot-wall of an ore deposit be too weak to support the stull in position, a false stull is usually placed to take the vertical pressure upon the foot of the stull as a diagonal thrust against the hanging-wall. The hanging-wall in this example represents sandstone and the foot-wall is of a talcose schist formation.

Dimensions are :—Stull, 7 ft. 6 in. by 1 ft. diam. ; false stull, 11 ft. 3 in. by 8 in. diam. ; distance between the stull sets, 4 ft. ; height from floor of level, 6 ft. An ore chute of the open bin gate type is included. Inv. 1916—18. S.M.781 L.S.

85. MODEL OF STULL AND SADDLE-BACK TIMBERING. (Scale 1 : 12.) Made in the Museum, 1915.

Stulls for vertical veins and ore deposits are often combined with a form of saddle-back timbering, as shown in this model.

In ore deposits that are more or less vertical it is necessary to resolve the vertical weight (due to the breaking down of the ore from the stopes above, and probably the filling-in with waste rock after the removal of the ore) into a diagonal thrust against the walls. This is carried out by the saddle-back system of timber bracing.

The dimensions of the timbers under the above conditions are as follow :—Stull, 13 ft. 3 in. by 12 in. diameter ; saddle timbers, 7 ft. by 9 in. diameter ; distance between the "sets," 3 ft. 6 in. ; lagging, 5 ft. by 3 to 4 in. diameter ; head-plate, 9 in. by 3 in. ; height of "drive," centre, 9 ft., sides, 6 ft.

Inv. 1915—425. S.M.739 L.S.

86. MODEL OF SADDLE-BACK STULLS WITH ORE CHUTE. (Scale 1 : 12.) Made in the Museum, 1915.

This form of timbering is sometimes used to carry "deads" or waste rock between levels and drifts, but is of little use to resist side pressure or movements from swelling ground.

Dimensions :—"Drift," 14 ft. 3 in. by 11 ft. 6 in. ; saddle timbers, 5 ft. 4 in. by 12 in. diam. and 9 ft. 4 in. by 12 in. diam. ; head plate, 3 in. by 12 in. ; distance between timber sets, 3 ft. 6 in. ; pole lagging, 5 ft. by 3 to 4 in. ; chute posts, 7 ft. by 6 in. ; chute opening, 18 in. by 12 in., ore chute cheeks of iron or wood 3 in. thick with recess for iron stopping rods, 2 ft. by 1 in. diameter.

A temporary ore chute is also shown for passing the ore down from any overhead stope before filling it with waste rock.

Inv. 1915—424. S.M.740 L.S

87. MODEL OF REINFORCED STULLS. (Scale 1 : 12.) Made in the Museum, 1916.

Where the ore deposits or veins are wide the stulls are often reinforced by another stull piece of timber placed beneath.

In this example the hanging-wall of the vein is at an angle of 50 deg. and the stull is set at an angle of 12·5 deg. from a right angle with the dip of the vein in accordance with the method illustrated in No. 81. The two stulls are further stiffened by placing three pieces of short timber between them. This enables the stulls to bear the side and vertical pressure from the breaking down of ore and waste filling from the stopes above.

Dimensions of the timbers :—Stulls, 12 ft. by 12 in. ; lower stull, 12 ft. by 10 in. ; cap pieces, 2 ft. by 12 in. by 3 in. The three pieces between the stulls are 15 in., 17 in., and 20 in. long by 8 in. diameter. Pole lagging, 4 in. diameter by 6 ft. 6 in. long. The stull sets are " hitched " into the foot-wall 4 ft. apart.

There is also a series of smaller stulls, 3 to 5 ft. by 6 in., with caps 2 ft. by 8 in. by 3 in. Inv. 1916—19. S.M.847 L.S.

88. MODEL OF " CHINAMAN " ORE CHUTE. (Scale 1 : 12.) Made in the Museum, 1916.

To deal with the ore within the mine after it has been won, and to load it into trucks, some form of chute or ore pass in the level is necessary, the type selected depending on the system of stoping adopted and on local conditions. The model represents the " Chinaman " chute, so named because it is stated, on somewhat slender authority, to have been first used by the Chinese. The chute is used with the shrinkage method of stoping (*see* No. 102) and modifications of it, where the stopes are kept filled with ore and no logged pass is necessary.

Beneath the ordinary stulls or drive sets of timber and about 5 ft. above the level of the rails, eight or more hitches on both sides of the drive, about 5 ft. centre to centre, are cut. Joists 8 in. by 6 in. are fitted into the hitches, and poles of about 3 in. diameter or else boards 2 in. thick, are laid upon them so as to leave a longitudinal opening which is closed by loose doors of hard wood, 2·33 ft. by 12 in. by 2 in. One or more trucks are run beneath the chute and the appropriate loose doors are drawn aside to let the ore fall into the trucks. To get access to the chute for the purpose of regulating the ore or breaking large pieces, a ladder is fixed at the end. Inv. 1916—332. S.M.840 L.S.

89. MODEL OF TIMBERING LEVEL SETS WITH STOPING BENEATH. (Scale 1 : 12.) Made in the Museum, 1915. Plate II., No. 2.

This represents a method of extracting the ore left, usually in the form of an arch, to support the floor of a level and workings above the stope.

Assuming the ore is too valuable to be left in, a start is usually made by placing two lengths of strong timber, called " stringers," close up against the posts of the timber sets, so as to extend over some four, five or more sets, according to requirements. Holes 1·5 in. diameter are bored into each post level with the top side of the stringer, and stout bolts are driven into each with the ends projecting right on the top of the stringer. The bolts keep up the posts, and the set is further stiffened by pieces of timber being wedged up under the cap and resting on the top of the bolts and stringer. A length of ore is then ready for breaking out according to the number of sets of timber strung on the supporting stringers.

At one end, where the lode is narrow, single stulls may be employed. At the other end, where the lode has widened out, saddle-back sets are used in place of stulls in securing the timber sets.

The dimensions are :—Timber sets, 4 ft. 6 in. by 5 ft. by 6 ft. 6 in., clear in the truckway ; posts and caps, 8 ft. by 9 in. ; sill, 6 ft. by 9 in. ; lagging, 8 in. by 2 in. ; stull pieces, 10 to 12 in. diameter ; bridge pieces, 6 in. by 9 in. ; stringers, 8 in. by 9 in. ; bolts, 1·5 in. diameter by 18 in.

Inv. 1915—429. S.M.742—4 L.S.

90. MODEL OF UNDERGROUND ORE BIN. (Scale 1: 50.) Made by Messrs. G. Cussons, Ltd., 1912.

In metalliferous mines where winding in skips is adopted, an ore bin is usually arranged under the station, at the junction of the shaft with the level, to receive the ore from the workings at that level.

The diagram model shows the arrangement of the main ore bins at the junction of the vertical part with the inclined portion of No. 2 shaft, Robinson Deep, Transvaal. Separate electric hoisting has been adopted for the latter portion. The bins are made by sinking a winze from the back of the station, at an incline usually of 45 deg. to the horizon, so as to open into the hoisting compartment of the vertical shaft at a point lower down than the landing place. By this arrangement the floor of the station is left solid.

(*See* Truscott, " Witwatersrand Goldfields, Banket and Mining Practice," 1898, p. 204.) M.4060.

91. MODEL OF TIMBERING FOR ORE BODIES (COMSTOCK SYSTEM) (Scale 1 : 12.) Received, 1883.

No efficient method had been developed for winning large underground bodies of ore, as distinct from vein mining, till square set timbering was introduced by Philip Deidesheimer about 1860, at the Ophir Mine, Comstock Lode, Nevada, after he had employed a closely similar method in mining a breast of ore 125 ft. wide at Forest Hill Mine, California. The method consists of building up rectangular cells framed of timber within the ore body as the ore is extracted.

The timbering of the stope is begun by laying down horizontal sill pieces ; at the intersections posts are erected and the tops of these are joined by caps and girts. This is repeated till the boundary of the deposit is reached, when short timbers are cut to suit and logs or planks are fixed against the country rock to prevent pieces falling in.

The timbers are rebated at their intersections so as to support one another and yet prevent relative movement, and it is in this important respect that modifications, further illustrated by adjoining models, have been introduced from time to time. As timber resists pressure best in line with the fibres, the design is such that the ends of the timbers under thrust butt against one another, while the rest are so rebated as to allow of this. In the Comstock lode timbering, illustrated by the model, the pressure is vertical and a short tenon at the foot of the post rests on the long upper tenon of the post beneath. The posts are 7 ft. 2 in. long over all ; the caps and girts are 3 ft. 9 in. in the clear both ways ; all are of timber 12 in. sq. Oregon pine is the timber used, and all the rebating, tenoning, etc., is done by special machinery on the surface.

Sometimes the pressure varies in direction within a comparatively short distance, when a combination of methods is required, *e.g.* diagonal struts must be used. At other times the pressure may be so great that no timbering by itself is sufficient, and the sets must be filled in with waste rock.

This extensive timber framework is subject to the ravages of insects and of vegetable organisms. To resist these, impregnation with preservatives is often adopted. In dry mines fire is a great source of danger. M.2797. 20811 L.S.

92. MODEL OF SQUARE SET TIMBERING. (Scale 1 : 12.) Presented by Cedric Vaughan, Esq., 1895.

This represents the timbering employed at the Hodbarrow hæmatite mine, Cumberland. The system is a modification of the Comstock timbering (*see* No. 91), but has the joint designed by Mr. Vaughan.

The posts have similar ends with short tenons and shoulder rebated out ; the ends of the caps and ties are rebated on three sides only. The timbering is 7 ft. in the clear both ways, while the distance in the direction of the working face is 4 ft. clear. A swing saw and mortising machine were put down for preparing the timber from pitch pine balks, 9 to 12 in. sq.

Although more expensive than the timbering used elsewhere in the district (*see* No. 67) it more than repays the extra cost by its strength and greater convenience. M.2763.

93. MODEL OF SQUARE SET TIMBERING FOR STOPES (EUREKA SYSTEM). (Scales 1 : 12 and 1 : 6.) Made from drawings prepared in the Museum, 1915.

This model shows the method of construction adopted at the Eureka Mine, Nevada, U.S.A., where the pressure to be met comes from the sides.

The system is used in some of the Anaconda mines in preference to the Anaconda method, as being simpler and cheaper. The model illustrates a case of timbering-up the hanging-wall and the kind of joint used in connecting the posts and caps with a wall plate. Should this prove insufficient, the sets are strengthened with diagonal struts. Douglas pine (*Pseudotsuga Douglasii*, Carr), often called Oregon pine, being straight grained and easily worked, is the timber mostly used.

The frame sets are composed of posts 7 ft. long and 10 in. sq. in cross section, having a short tenon 1 in. long, leaving shoulders 1 in. in width. The cap piece is 5 ft. 10 in. long and 10 in. by 8 in. cross section, with 1 in. shoulders ; the horns are cut 4 in. long so that the caps abut against one another in order to take the pressure direct. The girt piece is 4 ft. 8 in. long and 10 in. by 8 in. cross section, with 1 in. shoulders on two sides only. A model (scale 1 : 6) shows the joints at the junction of the three timbers. The dimensions in the clear of each set are 6 ft. 8 in. high by 5 ft. in the direction of the cap and 4·5 ft. in the direction of the girt. Inv. 1915—126. S.M.729 L.S.

94. MODEL OF SQUARE SET TIMBERING FOR STOPES (BINGHAM SYSTEM). (Scales 1 : 12 and 1 : 6.) Made from drawings prepared in the Museum, 1915.

This model shows the method of timbering in square sets used at Bingham Cañon, where, as in the Eureka system, pressure from opposite sides has to be met. It has been specially designed in order to economise timber without sacrificing strength, and was first used at the Highland Boy mine ; later, it was used by the Utah Consolidated and by the Cactus mine at Newhouse.

This economy is attained by making the post narrower in the direction of the cap than in that of the girt, instead of square as is usual ; also by making the girt narrower than the cap instead of the same cross section as is usual. The horns of the caps butt against one another. The top is rebated 4·5 in. to receive the bottom of the post, which is flush ; the top of the post has a short horn of 1 in. and shoulders 1·5 in. on each side to receive the cap piece. The girt piece is similarly rebated 1 in. on the top to receive the post. A separate model (scale 1 : 6) shows the joints where three timbers meet.

The dimensions of the timbers are :—Post, 6·75 ft. long and 10 in. by 9 in. cross section ; cap, 5 ft. long and 10 in. sq. ; girt, 4 ft. 5 in. long and 10 in. by 6 in. cross section. Inv. 1915—127. S.M.730 L.S.

95. MODEL OF SQUARE SET TIMBERING FOR STOPES (BURLINGAME SYSTEM). (Scale 1 : 12.) Made in the Museum, 1915. Plate II., No. 1.

This shows the " Burlingame " system of timbering wide chambers and stopes with square sets. The ore body here represents a " contact deposit," ore occurring between walls of country rock different in character. In this example the foot-wall is of sandstone and the hanging-wall of slate, *i.e.*, a good foot-wall but weak hanging-wall, giving considerable vertical pressure. A main-drive, or heading, is always kept well advanced along the course of the ore-deposit, and the work of extracting the ore is carried from wall to wall, and the method of erecting and fixing the sets of timbers is here shown.

As the stope is carried up, temporary flooring is laid down on the sets for the miners to stand on and break the ore down, and the ore passes are built up to shoot the ore down into the bin. Should the timber sets prove insufficient to hold the walls up, the sets are lagged up with poles and filled with waste rock.

This method of timbering is much like the " Eureka " system, the difference being that the post in the Eureka here forms the girt, the cap the post, and the girt the cap. The dimensions of the timbers are as follow :—

In the main sets, the posts are 7 ft. 5 in. long, 10 in. by 10 in. cross section. The top end of the post has a long tenon (" horn ") of 3 in. and shoulder rebated out 1 in. all round ; the bottom tenon or horn is 1 in. and is rebated out on two

sides only and juts into the sill piece. The sill pieces are 12 ft. by 10 in. by 10 in. The cap pieces are 5 ft. 4 in. long and 8 in. by 10 in. cross section, with tenon and shoulders rebated out 1 in. The girt pieces are 4 ft. 8 in. long, cross section also 8 in. by 10 in., tenon and shoulders 1 in. The inside dimensions of the main sets are 7 ft. by 5 ft. 2 in. capways, and 7 ft. by 4 ft. 6 in. girtways. The length of the posts in the ordinary sets (above the main sets) are 6 ft. 8 in., with horns cut to 3 in. both ends; the horns of the posts butt up against each other to take the vertical pressure. The inside dimensions of the girt and capways are the same as in the main sets, but the posts are 1 ft. shorter.

The main cross-cut timbers are 7 ft. 5 in. by 10 in. by 10 in., cap pieces 9 ft. 7 in. by 8 in. by 10 in., with rebate shoulders 5 in. to receive end of post. The centre post is 7 ft. 2 in. by 6 in. by 10 in., and the length of sill piece 12 ft. 6 in. by 10 in. by 10 in. Inside dimensions (footway) 9 ft. 8 in. wide, 7 ft. high, and sets 6 ft. apart, roof timber 9 in. by 2 in.; the sides are poled and filled with waste rock.

A single line of truck rails, 18 in. gauge, is laid through the main sets to the working face, main heading and ore bin; it is connected up also with a double track to transport the ore through the main level to the shaft.

Inv. 1915—331. S.M.679—80 L.S.

96. MODEL OF SQUARE SET TIMBERING WITH ROUND TIMBER. (Scale 1 : 12.) Made in the Museum, 1915.

This model represents a special method of timbering ore chambers and stopes with round timber, as used in Australia.

In remote mining districts the local conditions are of such a character as to render necessary the adoption of some system that will permit the use of round timber for square sets without the assistance of saw mills or machinery required in making such sets.

The sets are made up of the usual posts, caps and girts (Australian "stretchers"), and are cut from the rough felled timber that is delivered to the mines by the timbermen. The logs are usually specified to be not less than 7 ft. in length, with a minimum diameter of 10 in. The smaller ones are used for caps and stretchers, the larger ones for posts. The logs are stripped of all bark and cut to the required dimensions and shape by adzing and sawing. Accurate measuring angles and centering are attained by using a mitre box.

The dimensions of the timbers used are:—Posts, 6 ft. 4 in. by 10 in.; "horns," 2 in. long and 7 in. across; shoulders, 1·5 in. by 2 in.; caps and stretchers, 6 ft. 4 in. by 10 in. The horns, both ends, are cut 3·5 in. by 6 in., with shoulders of 2 in. The horns are mitred to a point to make close contact of all the timbers.

Some of the sets are lagged and timbered, where necessary for ore bins. convenient to the main hauling way and truck rails, so that the ore is transported through the main cross-cut from the shaft to the surface.

Inv. 1915—329. S.M.710—12 L.S.

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97. COMPOSITE PIT PROPS. Lent by Messrs. Mavor & Coulson, Ltd., 1913.

This form of prop, patented in 1913 by Mr. M. Mackay, is composed of a metal sheath enclosing a wooden post projecting 2 to 6 in. beyond the ends of the sheath.

Under compression the post shortens, fills the steel tube constituting the sheath, and, while taking some load itself, helps the latter to resist buckling. Great strength in proportion to weight, small space occupied and handiness are the advantages claimed.

Two similar props are shown: one, untested, has a tube 4 ft. 0·5 in. long, 4·5 in. diameter by 0·25 in. thick, and a post 4·4 in. longer; the whole weighs 53 lb. The other sustained a compressive load of 100 tons before buckling, the post shortening meanwhile 5 in., and the tube 0·6 in. Inv. 1913—1

SYSTEMS OF MINING.

98. MODEL SHOWING METHODS OF WINNING COAL. (Scale 1 : 600.) Presented by C. L. Wood, Esq., 1852.

The model represents a stratum of coal which is being removed by four different systems :—

A is the so-called " board and pillar " system, formerly employed in the Newcastle district. The whole of the ground to be taken away is divided into two sets of parallel galleries intersecting at right angles, thus leaving rectangular pillars of solid coal. When the galleries or " boards " have been carried out to the boundaries, the pillars are finally removed and the excavation allowed to close. As the pillars are of comparatively small size, they often give rise to a " creep " or thrusting-up of the floor.

B is an improvement of the above, also employed in the Newcastle district. Such a distance is kept between the two systems that they may be isolated, and the proportion of coal taken away in driving the boards is less, so that larger pillars are left.

C is the " long-wall " method of working, in which the coal is taken away in one breadth without leaving any pillars. The roadways, by which the coal is conveyed to the shaft, are carried through the waste or " goaf," the sides being kept up by walls made of the *debris*.

D is a modification of the " long-wall " method in which transverse lines of pillars are left at intervals, to support the roadway. In both C and D the working face is broken up by rectangular off-sets, the face nearest the shaft being kept a little in advance of its neighbour.

The whole area is worked from two adjacent shafts, one of which serves as the downcast and the other, provided with two furnaces, for the upcast. The air currents follow the direction of the arrows, and are directed by solid barriers or by double doors. Pins represent the timber props employed during the cutting of the coal. M.1393. 21,529 L.S.

99. MODEL SHOWING UNDERHAND STOPING. (Scale 1 : 96.) Made in the Museum, 1916.

This represents a method used for exploiting an ore deposit where the foot-wall is good but the hanging-wall is weak, and where filling in of the stopes with waste rock to support the wall is adopted.

So far the method is one that has been used from quite early times, the chief disadvantage being the cost of haulage from the bottom of the stopes.

The model shows an improved method of working, suitable, however, only for narrow veins, used at the present day. It consists in driving several levels and connecting these by winzes and rises at every 50 or 100 ft. Stoping commences around the tops of these winzes and the floor is kept cone-shaped so that the broken ore falls towards the winze, which later becomes the ore chute, a grizzly of logs being provided to prevent the large pieces choking it. When the winzes are large they are divided by a partition to give room for ventilation and for a ladder way. As stoping advances the distance from the roof increases and examination as to its condition is rendered increasingly difficult. To ensure the necessary working safety and to trim up any dangerous spots, ladders are rigged up as shown, and stayed by ropes secured to drill steel sets in the stope face. The arch of ore beneath the upper level is only removed when the stope has been nearly filled with waste rock. The level timbers are supported by the method shown in an adjoining model (*see* No. 89). Inv. 1916—343. S.M.869 L.S.

100. MODEL SHOWING RILL STOPING. (Scale 1 : 96.) Made in the Museum, 1917.

This sectional model represents the rill method of stoping out ore from a vein, a method that is often employed in veins of narrow to medium width and where filling is needed to support the walls. The name is given to it because the ore gravitates or " rills " in the ore passes or chutes.

Under favourable conditions the ore body is divided into blocks by levels about 100 ft. apart and by winzes 50—60 ft. distant from one another, but these dimensions will vary according to the character of the deposit. In the model, a section of a portion only of the mine is shown, comprising one of the waste shafts connected with the surface for filling the stoped-out ground. The stopes are

worked at angles with the horizontal between 35 deg. and 45 deg. The flatter angle is that shown in the model. At the steeper angle, should the width of the vein increase, the miner has to exercise considerable caution in moving from the working face. After a slice of ore from 10—15 ft. in height has been worked out and taken away, waste rock filling is let down the winze, and if the ore is of high grade a mat of boards, as shown, is laid on the waste filling to receive the next slice of ore. In the lower stopes the ore is supposed to be of low grade and no timber mat is used. This stope is in the process of being filled with waste rock.

Inv. 1917—67. S.M.1,037.

101. MODEL SHOWING FLAT BACK STOPING, OVERHAND SYSTEM. (Scale 1 : 96.) Made in the Museum, 1916.

In this method of stoping, the ore is broken out in a series of slices of a more or less regular shape extending the whole length and width of the vein between the winzes and walls, keeping the back (roof) as uniform and level as the nature of the ore will permit.

The model represents a contact ore deposit between a granite foot-wall and a schist hanging-wall (*i.e.*, a good foot-wall but a weak hanging-wall) ; the ore is supposed to stand well. As the ore is removed it is necessary to fill the stopes with waste rock ; this filling is distributed by a light car on a portable track, and is carried up to within 5 to 8 ft. of the roof. Ore chutes or passes are built up by cross-logging through the waste filling.

When waste rock is cheap the method is economical, not more than 5 per cent. of the ore being left in the mine. Prospecting work can be carried out from the stopes by means of cross-cuts, &c., and other development work can be carried out more conveniently than from a rill or a shrinkage stope (*see* Nos. 100 and 102). Another advantage is that the rich ore can be sorted out and the ore too poor to pay for treatment can be left behind. The disadvantage of the method, particularly in large stopes, is the cost of transport of the ore to the passes, owing to the shovelling and trucking involved. In some cases this is reduced by the use of wheelbarrows. A corresponding drawback occurs when the stope is being filled, as much shovelling is necessary to distribute the waste rock.

Inv. 1916—342. S.M.843 L.S.

102. MODEL SHOWING SHRINKAGE STOPING. (Scale 1 : 96.) Made in the Museum, 1916.

This model shows a system of mining where the ore is allowed to accumulate in the stope and form a working floor for the miner.

The model represents this method being carried out on an ore-deposit or vein of a width of from 12 to 16 ft. and nearly vertical. Levels, cross-cuts, and drifts have been driven at the 60 ft. and 160 ft. levels. Stull timbering (*see* No. 81) of the levels and drives is used where required. Ore chutes are erected between the stull sets every 20 to 25 ft. on the foot-wall side of the drive. A small prospecting shaft is shown and is utilised for ventilation and for a ladder way. To the right of the shaft some blocks of lean ore have been left untouched. At the 60 ft. level, on the right of the shaft, it will be seen that the broken ore has been drawn off and the empty stope has been filled in with waste rock through a winze from the surface. To the left of the shaft the broken ore is being drawn off. In the lower stope, at the 160 ft. level, the ore is in process of being broken down to fill the stope.

This method of stoping under the favourable conditions of good walls and inclination, ore of even grade so that no prospecting is required, and absence of " horses of country rock," is very economical, but it can only be adopted in a limited number of mines. Inv. 1916—344. S.M.870 L.S.

103. MODEL SHOWING GILMAN CUT-AND-FILL SYSTEM. (Scale 1 : 64.) Made in the Museum, 1917. Plate II., No. 3.

This shows a method of mining used extensively in Arizona, and, with various adaptations, in stoping the large sulphide ore bodies found in this and other mining districts of the U.S.A. The method is said to have been named after an American engineer who introduced it.

The system consists in blocking out the ore in sections of 40-50 ft. with cross-cuts, driven from the main drive to the limits of the ore body on the hanging and foot-wall sides (a section of the stope on the foot-wall side of the drive is represented). Vertical raises are driven upwards from the cross-cuts connected with

winzes sunk from the upper level; later these provide a means of filling the stope with waste rock and serve for ore chutes and passes. These cross-cuts are the first step in stoping, and the next step consists in widening the ground a little at the side of the cross-cut to permit the temporary timbers to be placed in position. Flooring is laid so as to allow the ore to fall, by removing the short planks, into the trucks below. When sufficient ground has been broken out these temporary sets are replaced by regular timber sets of posts, inclined caps and vertical sills, with planks to form a mat between the " gob " of waste rock and the ore below and along either side. After each successive ore cut from 10-12 ft. above the floor, the ore is drawn off, the floors taken up, and the waste rock run in to the desired height. The floor is then relaid to receive the next cut. In the earlier stages of stoping, all the ore is not removed as soon as broken down, but is allowed to accumulate as a floor for the miner to stand on.

The work at successive stages, numbered 1, 2, 3 and 4, and the method of timbering the workings are shown. Inv. 1917—70. S.M,1040.

104. MODEL SHOWING TOP SLICING STOPE. (Scale 1 : 96.) Made in the Museum, 1917.

This sectional model represents a method of extraction used principally in mining large soft ore bodies. The system is a modification of the " long-wall " retreating method worked under an artificial roof of timber called a mat.

The top of the ore-body is removed either by open stoping or sub-level caving (*see* No. 106) and a double floor of plank 2 in. thick is laid down. The overburden is then caved in on top of the mat. A car level is laid out at about 50 ft. below the mat and the ore is divided by drifts, winzes and raises into blocks 30 to 40 ft. wide. Commencing at the boundary or walls of the ore, slices 11 ft. in height by 30 to 40 ft. wide are mined beneath the mat, which is supported meanwhile by posts and round unframed caps. As the slicing advances the timber mat is caved by blasting the posts behind the working face.

This method allows a larger and more regular output from the working faces than if square set timbering is used, but, owing to the rough floor and other conditions, the breaking and shovelling of the ore is not done so economically; the amount of timber used, however, as compared with square sets, is small.

Inv. 1917—68. S.M.1038.

105. MODEL SHOWING BLOCK SLICING. (Scale 1 : 96.) Made in the Museum, 1917.

This sectional model represents a method of working out a large ore-deposit from the surface by horizontal block slicing, with ore transportation facilities at a lower level.

This system can only be applied where the ore deposit is very extensive, the walls good and at some convenient height to permit of the broken ore gravitating through the ore passes to a main adit haulage level beneath the workings. The working level is divided into blocks by cross-cuts every 40 ft. from the main drift towards the foot and hanging-walls (only the foot-wall side is shown in the model). The ore is mined by slicing or under-cutting and retreating towards the drift. Untimbered ore chutes connect up with the main haulage level to receive the ore trammed from the working faces.

Block slicing allows of a regular and large output from many working faces, but there is a considerable amount of cross-cutting and of shovelling on a rough floor. As one floor or level is being worked out, the next one 10, 15, or 20 ft. below it is in preparation. The minimum working height is 10 ft. in the faces.

Inv. 1917—69. S.M.1039.

106. MODEL OF SUB-LEVEL CAVING SYSTEM. (Scale 1 : 96.) Made in the Museum, 1916.

This model represents a method commonly employed, in the large hæmatite and iron mines of the North American Continent, in mining the upper part of an ore body before top-slicing is resorted to.

Slices from 40 to 50 ft. wide and about 20-25 ft. below the caved ground are cut by drifts. The back of the ore is mined by the work retreating, and the capping and waste rock are allowed to cave in. The ore is passed down through the winzes to the haulage levels below and raised by the main shaft. When necessary the winzes are partitioned off for ladder ways and ventilation.

The principal drawback to the method is the inevitable lowering of the grade of ore through admixture with waste rock, as no timber mat is used between the ore and the waste rock. Inv. 1916—345. S.M.1036.

107. MODEL SHOWING MILLING SYSTEM OF MINING. (Scale 1 : 96.) Made in the Museum, 1919.

The milling system of mining is a combination of open cut quarrying and underground development work that is now usually applied to the opening up of very large ore deposits. The model represents the system applied to a deposit of iron ore.

The barren ground or overburden covering the ore body is removed by the steam shovel in a series of benches or terraces, and the superficial portions of the ore, which is oxidised and therefore comparatively soft, is removed similarly. When the ore deposit has been thus developed on the surface, it is opened up with levels, cross-cuts, winzes, and rises from a main shaft in the usual way. The winzes sunk from the surface benches enable the ore to be stoped out underhand around these points so gradually enlarging the winzes till they form milling pits. The ore gravitates into the chutes and is transported along the levels to the main hauling shaft.

The lower level shows the method of opening up by means of rises and overhand stoping gradually enlarging the rises so as to form a long chamber ; this is known as the " glory-hole " method of working.

The advantage of the system is that it is capable of giving a very large output with a minimum amount of handling the ore at a low mining cost. The disadvantages are : the difficulties of sorting waste rock from ore, the liability of the milling pits and winzes to get choked, and the interference with the surface work and the milling pits that may be caused by weather conditions.

Inv. 1919—459. S.M.1162.

108. MODEL SHOWING ORE IN SIGHT. (Scale 1 : 96.) Made in the Museum, 1917.

This model represents the " blocking " out of ore in a mine and illustrates some of the difficulties met with in estimating the quantity of ore *in situ*.

One of the purposes of blocking out the ore in a mine by drifts, winzes and raises—in addition to the primary one of the work of extraction—is to expose the boundaries of the ore deposit in three dimensions for the purpose of estimating quantities and values contained in the deposit. Owing to the irregular way in which ore deposits occur, such estimates may vary considerably.

The Institution of Mining and Metallurgy, recognising the importance to the mining industry and to the public generally of defining the terms " Ore in Sight," appointed a Committee to consider what steps might be taken in the matter. After report and consideration, the Institution made the following recommendations :—

(1) That Members of the Institution should not make use of the term " Ore in sight " in their reports without indicating in the most explicit manner the data upon which the estimate is based ; and that it is most desirable that estimates should be illustrated by drawings.

(2) That as the term " Ore in sight " is frequently used to indicate two separate factors in an estimate, namely :—

(*a*) Ore blocked out—that is, ore exposed on at least three sides within reasonable distance of each other ; and

(*b*) Ore which may be reasonably assumed to exist though not actually " blocked out " ;

these two factors should in all cases be kept distinct, as (*a*) is governed by fixed rules, whilst (*b*) is dependent upon individual judgment and local experience.

(3) That in making use of the term " Ore in sight " an engineer should demonstrate that the ore so denominated is capable of being profitably extracted under the working conditions obtaining in the district.

The model illustrates these recommendations : at B B the ore is blocked out on four sides into 50 ft. blocks. At C the ore is blocked out on three sides, but as the top drift is partly in barren ground owing to the lode not outcropping to the surface, the difficulty of estimation is increased. At D the ore is blocked out on four sides into 100 ft. blocks ; at L and T indications of intrusions of barren rock of unknown extent occur. (In the case represented, on extraction of the ore,

the barren mass was found to be of the shape shown by the dotted lines.) At E the ore is blocked out on three sides, but no winze has been sunk at Z ; the character of the ore at this point, however, may reasonably be assumed from the data supplied by the drifts above and below. The same remark applies to G G.

The blue lines every 5 to 10 ft. indicate the points where samples for assaying are taken. Inv. 1917—71. S.M.1041.

HAULAGE AND HOISTING.

109. MODEL OF SELF-ACTING INCLINE. (Scale 1 : 24.) Made by Herr Carl Schumann.

This form of haulage in which the full wagon draws up the empty one is convenient and economical where the incline available is at least 1 in 30.

In the simple arrangement shown, which is for use underground, the timbering is of round posts with a cap supporting boards. The incline is 1 in 7, and the wagons are attached to ropes which wind in opposite directions on two horizontal drums at the summit of the incline. A wooden brake lever is forced on the shaft between the drums to control the speed. There are two lines of rails, but in long roads it is usual to reduce the number of rails to three, or even two, and use turnouts where the wagons pass one another. Usually also a level section at each end of the incline, on which to prepare the wagons, is provided, and also a steeper section near the summit by which to accelerate the starting load quickly and so increase the average speed. M.2791. 21,050 L.S.

110. MODEL OF SELF-ACTING INCLINE (Scale 1 : 18.) Presented by Messrs. J. & J. W. Pease & Co., 1862.

This incline is situated at the Upleatham ironstone mines in the North Riding of Yorkshire, and is used to lower the stone from the headways (*see* No. 163), which are driven into the face of the cliff, to the level of a branch of the North Eastern Railway.

The ore is drawn from the workings in small trucks of 20 in. gauge, hauled by wire rope driven by steam power, and then taken by locomotives to the head of the incline. After passing a weigh-bridge each truck enters a tipping cage controlled by a strap-brake, which discharges the stone into an inclined shoot closed by a flap also controlled by a strap-brake. This shoot, which holds the contents of several of the small trucks, then discharges into 3-ton wagons in the deep level cutting at the head of the incline. A train of loaded wagons being made up, it is lowered down the incline by a wire rope from a double drum, which, at the same time, winds up a train of empty wagons. The drums are of cast iron, with wrought iron strap-brakes controlled by a hand lever.

In the model, the portion of the incline shown, which is 1 in 16, has been cut into three lengths and placed side by side, to reduce the length.

M.1409. 21,217 L.S.

111. MODELS OF SKIPS. (Scale 1 : 8.)

The skips used in Saxony are of wood bound with iron straps and lined with sheet iron. Two straps passing round the sides and bottom carry the guide rollers, and by two short chains form the attachment for the hoisting rope. One of the skips has a hinged door.

The skip used in Cornwall is made entirely of iron. It runs on four rollers and has four projecting plates beneath to keep it on the guides. There is a hinged door in front with a gravity-locked bolt. Flat rope is used. M.2819.

112. MODELS OF WAGONS AND TRAMROADS. (Scales 1 : 10 and 1 : 12.)

The simple wooden end-tipping wagons are used in Saxony. The body rests on a single timber to which the axles are attached, and this block is made sufficiently deep to allow the wheels to be wholly under the floor for protection. The stress on the axles is reduced by iron plates, extending from the sides of the wagon to the axles. The wagon road is raised above the floor of the level to give space for a waterway ; in one model the road is laid with **T**-headed rails, and in the other with flat iron set on edge.

The wagon used in Cornwall is wholly of iron. The body is set forward on the frame so that it nearly balances on one of the axles on which it tips upon releasing a catch at the rear. The end door is hinged and retained by a bolt at the bottom. The wheels are protected by a guard on each side riveted to the body. As in the previous cases, the wheels are loose on the axles. M.2817-8.

113. MODEL OF END-TIPPING ORE TRUCK. (Scale 1 : 6.) Made in the Museum, 1919.

This simple form of end-tipping truck is one that is used for the transport of ore from the mine face and workings to the ore bins, and for short haulage purposes generally.

The underframe is of hard wood carried on two square axles with loose flanged wheels 10 in. diameter by 18 in. gauge. The body is of mild steel 0·125 in. thick, the bottom and sides being bent from a single plate which is riveted to angles at the ends. The bottom is protected by a renewable wooden floor. The door is hinged at the top, and its locking bolt is operated from a lever at the rear. As the centre of gravity of the body is only a short distance back from the centre of the underframe, a slight lift from the rear handle tips the truck. The capacity is 12 cub. ft. Inv. 1919—397.

114. MODEL OF ALL-ROUND TIPPING TRUCK. (Scale 1 : 5.) Made in the Museum, 1920.

The economic handling of ore and waste rock in a mine is largely dependent upon the means provided for transporting them. The usual means is by a truck or car on rails ; the model shows a useful form which permits discharge of the load at either end or at either side.

The box-shaped body with end-hung discharging door is mounted on a turn-table, the pin of which is set forward 2 in. in front of the centre of the under-carriage. The horizontal bolt on which the body tips is set forward 4 in. from the turn-table centre. A slight lift from the rear handle bar is all that is necessary to tilt the body over the centre. A rear lock and a door lock are provided controlled by a single lever at the rear.

The body of the truck is 36 in. long, 24 in. wide and 18 in. deep, i.e., capacity 1 cub. yd. The height from the rails is 36 in. The body is of mild steel 0·125 in. thick with steel angles 1·5 in. by 1·5 in. at the corners. The bottom is also of steel 0·187 in. thick covered with wood 1 in. thick. The turn-table consists of 2 cast steel plates 14 in. diameter. The under-carriage is of wood with wheels 10 in. diameter by 2 in. wide loose on the axles, and the gauge is 18 in.

Inv. 1920—83. S.M.1231.

115. HAULAGE CLIP. Presented by J. W. Smallman, Esq., 1889.

This clip is for rapidly attaching a tub or wagon to the wire haulage rope travelling along the mine road ; the form shown was patented in 1883 by Mr. Smallman. Two cheeks, tied together by a bolt, are extended at the lower part to form two jaws 4·5 in. long, which are lined with soft iron. The insides of the cheeks are formed as inclined planes upon which works a block at the end of a clamping lever pivoted loosely in the cheeks. The lever forces the cheeks outward so causing the jaws to grip the rope. The shackle is for attachment to the tub or wagon. M.2787.

116. MODEL OF MINING WINDLASS. (Scale 1 : 12.) Presented by J. Lace, Esq., 1893.

This model shows a simple form. The axle is a square iron bar lagged with two pieces of oak turned cylindrical after fixing. It is supported over the shaft by bearings in two iron brackets fixed to uprights at a height of about 3 ft. above the platform level. The uprights are tenoned into two cross-pieces and stayed by inclined struts ; the axle is locked by a catch fitting over the square part. A sliding board closes the mouth of the shaft when the bucket is not being drawn through ; it is further protected by a sloping board resting on the struts. M.2780. 20,808L.S.

117. MODELS OF SAXON WINDLASSES. (Scale 1 *8.)*

The first is similar to No. 116, but there is a space at one end covered by a trap door through which the ladders can be reached. The axle, which is 6 ft. long by 10 in. diameter, is supported on the top of two uprights ; a horizontal rail is provided to assist the workman when lifting the loaded bucket away from the mouth of the shaft. The windlass is locked by a pin, pushed into a hole in one of the uprights.

The second is intended for heavier work, and is geared in the ratio of 3 : 1 ; the axle is 5·3 ft. long and 15 in. diameter. M.2636-7. 20,808 L.S.

118. MODEL OF SAXON HAND WHIM. (Scale 1 : 12.)

This is a form of capstan with the drum above, arranged for working by three men ; as the whim cannot be placed directly over the shaft, guide pulleys and frames are necessary. The ore is held in wooden skips on which are rollers running between two wooden guides, and the skip is tipped by a projecting iron rod fixed at a short distance above the pit top ; the two ends of the rod form bolts which are shot forward and retain the skip when it is lowered, while the upper end of the skip falls forward and discharges the contents over a wooden apron which directs the ore into a wagon. A brake fixed to the lower drum and worked by a hand lever controls the motion at any point.

The wagon shown is the Hungarian " hund " ; it has two pairs of wheels of unequal diameter. The miner presses the handle at the back so that the load rests on the big wheels which run on a plankway. M.2638. 20,801 L.S.

119. MODEL OF CORNISH HORSE WHIM OR GIN. (Scale 1 : 12.) Made by T. B. Jordan, Esq. Received 1842.

This is a winding gear specially constructed for being worked by horse power. Before the introduction of the steam engine these machines were generally used for raising the ore from mines and, for temporary works, this arrangement is still frequently adopted.

The horses are harnessed to two radial arms built into an upright axle, on which is a drum 12 ft. diameter by 4·6 ft. long, formed of boards nailed to three wooden rings secured to the upper portion of the axle. The top bearing of the axle is carried by a timber framing, to which the framing for the pulley of the rope or chain over the pit's mouth is also secured.

The circular path described by the horses is 36 ft. diameter, and the load is raised at a speed of 75 to 100 ft. per min. in kibbles holding about 280 lb. ; for depths exceeding 240 ft. two horses are generally employed. M.1392.

A print shows a similar whim in use at Lindal Moor Mines, Lancashire, in 1900, raising 15 tons of ore per day of 8 hours from a depth of 60 ft. M.4157.

120. MODEL OF SAXON HORSE WHIM. (Scale 1 : 24.)

The axle is 23 ft. in length, and has the rope drums placed on its upper end as in the hand whim ; the horses are harnessed to a turning bar attached to the lower end of a diagonal arm. The lower drum is rigidly fixed to the axle, while the upper drum is connected to the lower one by a wooden pin, which when withdrawn enables the lengths of the ropes to be adjusted, so that when one bucket is at the level the other shall be at the surface. In making the adjustment the upper drum is fixed by the brake and the lower one turned round to the required amount. The upper drum runs on friction rollers on the upper surface of the lower one, and the brake works on the lower projecting rim of the upper drum. The foot-step bearing of the axle rests upon a pair of adjusting wedges on a short pillar of masonry ; the top is attached to a horizontal beam carried by two diagonal struts which also support a conical roof covering the drums. To take the load from the horses when the whim is stopped, two poles with spiked ends are dragged round with the horse-pole. M.2639. 20,800 L.S.

121. MODEL OF CORNISH WATER WHIM. (Scale 1 : 12.) Made by J. Arthur, Esq. Received 1843.

This shows a method of raising material from mines by water power.. A simple overshot water-wheel drives, by spur gearing, a horizontal shaft on which are fixed two bevel wheels, and this shaft can slide in its bearings

sufficiently to bring either of the bevel wheels into gear with a third bevel wheel connected with the winding drum ; by this arrangement the direction of winding is reversed. The drum shaft is provided with a strap brake, and there is an arrangement by which a weight sliding in front of a signal board indicates the position of the bucket or kibble. These kibbles each hold about 3·5 cwt. of ore. M.1383.

122. MODEL OF WATER WHIM USED IN THE HARZ MINES. (Scale 1 : 18 for the wheel and 1 : 12 for the winding gear.)

This arrangement was formerly adopted underground in some German mines, for utilising water power for winding in shafts which do not come to the surface.

An overshot water-wheel, 29·25 ft. diameter by 5·5 ft. broad, is provided with two sets of buckets opening in opposite directions ; each set is supplied from a separate sluice (not shown in the model) so that the wheel can be rotated in either direction, an arrangement described by Agricola in 1554 and introduced into the north of England about 1778. The model shows in detail the construction of this double wheel in timber. The two winding drums, 8·5 ft. diameter are on the same shaft as the water-wheel ; the one nearest it is made entirely of wood and fixed to the shaft, while the other is loose and carried by six cast-iron arms on either side turning on a pair of cast-iron rings keyed on the shaft ; each of these rings has four square holes in it to receive the locking hooks, which by an external lever may be caused to lock the drum to the shaft in any position. This arrangement allows of winding from different depths, by adjusting the lengths of the two ropes ; brakes on each edge of the loose drum are provided. A wooden brake-wheel 12 ft. diameter is fixed to the main shaft, which is 23 in. square and has journals 6 in. diameter. M.2640. 20,809 L.S.

123. MODEL OF SAXON TURBINE WHIM. (Scale 1 : 12.) Received 1868.

This represents the system of winding adopted about 1856 at the Oberes Neues Geschrei Mine, Freiberg, where the shaft was sunk on the vein, dipping at an angle of 70 deg. All the machinery was underground, but was controlled from the surface by rods.

Power was supplied by the discharge of 75 cub. ft. of water per min. under a head of 97·5 ft. which was utilised to drive either of two turbines placed side by side on the same shaft, one for backward and the other for forward motion. The turbines are of the kind introduced into Saxony about 1849 by Schwamkrug with radial outward flow, the water entering a part of the circumference only, so that a large wheel can be used and thus the speed of revolution be reduced. The rings of buckets are attached to a stout disc which serves also as a brake drum, and the speed is reduced in the ratio of 14 : 1 by the gearing connecting the wheels with the winding drum. The supply nozzle gives a rectangular jet which is adjustable in area by a movable flap.

The tub or skips carried about 8 cwt. and ran on rollers between wooden guides ; there was a tipping gear worked by a lever for emptying them. M.1414.

124. MODEL OF STEAM WHIM. (Scale 1 : 12.) Made by T. B. Jordan, Esq., 1843.

This arrangement was once common in Cornwall for winding from shallow shafts by steam power. The model shows a plant designed by Mr. J. Sims and erected at East Wheal Crofty.

A beam engine, by means of bevel gearing, turns two horizontal winding drums 4 ft. diameter ; these are so arranged that the engine can wind from two shafts at the same time, guide pulleys and frames of simple construction directing and supporting the chain to the shafts. The mouth of each shaft is protected by two hinged doors with a slit in the middle of each for the passage of the chains ; the ascending kibble raises the doors, which fall down as soon as it has passed. The ore is brought up in kibbles of wrought iron, which hold from 5 to 7 cwt. M.2641. 21,221 L.S.

125. MODEL OF SKIP-WAY ADAPTED FOR WINDING. (Scale 1 : 24.) Presented by Capt. Wm. Teague, jun., 1882.

This is a model of a skip-way which was in use at Dolcoath and Tincroft mines, Cornwall. It represents a common form of way arising from the practice of following the lode closely.

Where the skip-way is vertical or nearly so, four timber guides are used so as to completely control the skips, but where less inclined the lower guides only are retained, as the weight of the skips then keeps them steady, while their absence saves timber, and also leaves the skips more accessible. At the top of the model is seen the flap that retains the skip at the surface when being discharged. The skip is shown in an adjoining case. M.2790, 20,884 L.S.

126. MODEL OF SKIP-WAY FOR A CROOKED SHAFT. (Scale 1 : 24.) Presented by Capt. Wm. Teague, jun., 1882.

The model shows an extreme case of a crooked shaft, the result of following a lode downwards on its dip.

The skips used in Cornwall are sheet-iron boxes running between wooden guides, and usually have two rollers and two slippers on each side. In such an exceptionally crooked way as that shown there were no slippers to the skips, but four wheels on each side (*see* model in adjoining case), so that on the reversed part of the curve also the load on the guides should be carried on rollers. The hauling rope is retained in a central position in the shaft by numerous wooden rollers on the concave side of the course. The method of loading the skip from a chute at any particular level is shown. M.2789. 20,879 L.S.

127. MODEL OF WINDING ARRANGEMENTS. (Scale 1 : 48.) Presented by Capt. Wm. Teague, jun., 1882.

This is a diagrammatic model showing the winding and pumping arrangements adopted in working the Highburrow lode at the Carn Brea mines at Redruth, Cornwall. To render the model more compact, the distances apart of the shafts and adits have been much reduced.

On the left is shown a shaft, fitted with guides for winding, and a set of mining pump rods that work pumps which divide the total lift into three stages. The water raised is delivered into an adit considerably below the top of the shaft. From these rods power is, moreover, transmitted by inclined rods and bell-cranks to a pump in another section of the mine. On the right is represented a winding shaft, with timber guides for the skips, and also an inclined skipway running into it close to the surface. One of the skips is also shown. M.2789a.

128. KOEPE WINDING SYSTEM FOR DEEP MINES. (Scale about 1 : 50.) Made by Messrs. G. Cussons, Ltd., 1912.

In ordinary practice the load on the winding engine, due to the weight of the rope, is greatest at the start and diminishes as the winding proceeds. To obviate these disadvantages, which increase with the depth, other methods have been introduced.

The diagram model shows the system introduced in Westphalia in 1877 by Herr E. Koepe. This consists essentially of an endless rope with the cages interposed, wound in opposite directions alternately. In practice, the rope passes from one cage over a pulley on the pit-head frame to the engine-driven pulley, round which it makes about half a turn ; it then passes over the other pulley at the pit-head to the second cage. Another rope hangs from the undersides of the cages in a loop, or is passed round a pulley.

The advantages are that the load on the engine during winding is uniform and that a simple pulley takes the place of the cumbrous winding drum. A drawback is that the friction between the rope and the groove of the pulley is not always sufficient to prevent slip, and thus the position of the indicator may be altered. M.4061.

129. MODEL OF PIT SHAFT WITH CAGE AND GUIDES. (Scale 1 : 12.) Presented by T. Sopwith, Esq., F.R.S., 1853.

The earliest system for raising coal in the pit appears to have been in " corves," *i.e.*, wicker baskets hung loosely from the lifting rope. The only improvement seems to have been the provision of a partition to separate the ascending from the descending corves. John Curr, in 1788, patented the use of guides in which worked a cross-bar carrying the corves. This was not generally adopted outside the Sheffield district. With the advent of the steam engine greater speeds became possible, and were necessary as greater depths were reached. It was not, however, till 1835 that the present arrangement, combining the use of guides with a cage in which wheeled tubs from the working faces were raised to the surface, was after several trials brought to a success at Woodside, near Ryton-on-Tyne, by Mr. T. Y. Hall. It was found possible to deal with a much greater quantity of coal than before, and the new system rapidly extended into all districts.

The model was made in 1835, and shows a rectangular cage of wrought iron bars with a wooden floor having rails for the tub. The flat hempen lifting rope is attached to the cage by four chains and a spring hook. The pit guides are flat iron bars spiked to the face of continuous timbers ; above the pit bank the guides are of lighter section, and at right angles to the position of the former ; the shoes on the cage are of channel section ; " keps " to rest the cages on during the time of changing the tubs were also applied. These were simply hinged frames caused to swing inward under the cage by a lever. The pit-head pulleys are of cast-iron, carried in a timber framing strengthened by inclined struts. (*See* Min. Journ., XXVIII., 1858, p. 655.) M.1403. 21,466 L.S.

130. MODEL OF PIT-HEAD FRAME AND CAGE. (Scale 1 : 16.) Presented by H.G. the Duke of Buccleuch, K.T., 1844.

This shows an early form of cage, which was used at Cowden Colliery, Dalkeith, N.B., consisting simply of a platform supported from the flat winding rope by chains attached to iron uprights, which carry shoes that embrace the wooden guides. Modern cages, being also used to convey the miners, are closed at the sides, while the ends have light detachable gates. In America, however, a cage like the one in the model, with the addition of a hood, is common. To support the cage at exactly the right level while the full wagon is being replaced by an empty one, catches consisting of planks running across the shaft, set on edge and hinged below, are secured so that their upper edges may project a little into the cage space. By a hand lever both catches can be moved back so as to leave the shaft clear. Flat rope is used, working on a reel or bobbin with long horns, the rope coiling upon itself. Large pulleys are used in the pit-head frame, which consists of a pair of upright legs stayed in the direction of the drum by long wooden struts. M.2785. 20,785 L.S.

131. MODEL OF CAGES AND GUIDES. (Scale 1 : 12.) Presented by G. B. Forster, Esq., 1862.

The pair of cages shown are arranged for carrying four wagons each. They are built of flat iron bars with diagonal braces, and have a wrought-iron roof and two decks. The guides are a pair of flat-footed rails, arranged on one side only, and secured to cross sleepers placed 6 ft. apart through the entire depth of the shaft. The case has three pairs of crescent-shaped slippers riveted to its guided face. M.1404. 21,072 L.S.

132. MODEL OF PIT-HEAD FRAME AND CAGES. (Scale 1 : 12.) Contributed by W. H. Jordan, Esq., 1865.

The overhead pulleys are carried by a braced timber framing, the members of which are secured together by long tie-bars and angle plates. One of the back legs is provided with steps and a hand-rail, by which the bearings of the overhead pulleys can be readily reached. The pulleys have cast-iron grooved rims and wrought-iron arms.

The shaft has three timber guides for controlling the two cages, and these guides also form gripping surfaces for the safety gear, which automatically

comes into action should the rope break. The catches consist of two levers on each side of the cages, the outer ends of these levers being pulled down by springs that tend to close the catches on to the guides; the pull of the lifting rope is partly felt by these levers, and, as its action is greater than that of the springs, the safety catches are swung clear of the guides so long as the pull of the hauling rope is maintained.

The guides are carried to the pit-head frame and are employed to support the cage in the event of overwinding, but in later arrangements a form of detaching hook is usually employed which will itself retain the cage when overwound, independently of the safety catches. The detaching hook shown, however, consists of three plates provided with notched slots, into which the hoisting tackle of the cage fits. The notches are kept out of line by a spring, but when overwinding occurs the hook is pulled through a conical socket that pushes the three slots into line, so releasing the cage and allowing the winding rope to run freely through without being broken.

The cages are single decked, framed in iron, closely boarded, and provided with a semi-circular roof; the floor of each cage has a catch that retains the trucks in position by their axles. When at the ground level, the cages are retained by four side catches, each of which has to be withdrawn by treadle levers before a descent can be made. M.2644. 21,070 L.S.

133. MODEL OF CAGE WITH LOADING GEAR. (Scale 1 : 8.) Lent by B. Woodworth, Esq., 1893.

This shows a two-decked cage fitted with the "automatic controllers," patented in 1890 and 1892 by Mr. Woodworth, by which the requisite number of wagons are automatically passed into the cage and there locked, and again released without requiring "scotching" or personal attendance. In the model the cage has its lower deck arranged for tilting, and is fitted with controllers at each end to allow for loading and unloading at opposite ends, if required, but the upper deck is on a fixed incline with single controllers only. A controller consists of an arm which swings upward so as to catch the wagon axle, and which can be depressed by a bolt moved by a lever on the side of the cage, either automatically or by hand. As the wagon axles pass over the controller each axle partly rotates a star wheel which, after two or more axles have passed, throws back the bolt and allows the arm to lift and so prevent more wagons passing. For safety, two controllers acting on the same axle are used.
M.2542. 20,803 L.S.

134. MODEL OF CAGE WITH SAFETY CATCHES AND DISCONNECTING HOOK. (Scale 1 : 6.) Received 1851.

The model shows Messrs. White and Grant's catches and hooks introduced about 1850. The cage is a simple stirrup frame, with a platform having rails for two wagons side by side. The guides are of timber, and the slippers of channel iron; the safety catches consist of four eccentric discs keyed on each end of two horizontal shafts carried in bearings on the top of the cage. These catch shafts are turned by the action of springs that tend so to rotate them as to close the catches on to the guides, but the pull of the hauling rope tends to rotate them in the reverse directions.

The disconnecting hook consists of a hook in a frame, engaging in an eye secured to the end of the lifting rope; the hook has a projecting tail which, when overwinding occurs, strikes the overhead framing, and so turns the hook as to release the rope, the guides and safety catches then support the cage. M.1399.

135. CAGE WITH SAFETY CATCHES. (Scale 1 : 12.) Contributed by Andrew Knowles, Esq., 1862.

This is a light cage with a metal roof and floor; it is guided by four channel-shaped slippers working on timber guides. On each side is also a plate that carries the fulcrums of two catch levers whose gripping surfaces are formed with teeth; the catches are forced up by four separate springs, which are, however, overpowered by the pull of the hoisting rope so long as the rope is intact. In the model a wagon is shown in the cage retained in position by two connected end clips. This form of safety gear was patented by Mr. James Owen

in 1857, and soon extensively adopted in Lancashire ; in one case a load of two tons, moving at the rate of 10 ft. per second, was brought to rest in a distance of 3 ft. after the breaking of the rope, while in two other cases loads of 15 cwt. and 41 cwt. were stopped after a fall of 1·5 and 2·5 in. respectively. M.1391.

136. MODEL OF SKIP WITH SAFETY GEAR. (Scale 1 : 5.) Contributed by W. Bennetts, Esq., 1862.

A Cornish skip with four wheels and slippers (*see* No. 111), is shown with its guides. The safety gear, patented in 1859 by Mr. Bennetts, consists of two-toothed levers, pivoted on the same centres as the upper wheels, and is forced on to the guides by volute springs when not overcome by the pull of the hoisting chain transmitted to them by levers attached to the crutch which moves in slotted holes in the skip. M.1386.

137. MODEL OF CAGE WITH SAFETY CATCHES AND DISCONNECTING HOOK. (Scale 1 : 8.) Contributed by J. T. Calow, Esq., 1862.

The cage has a pyramidal roof covering the safety gear. The catches are applied by a weight, supported by a coiled spring in a vertical cylinder. If the rope breaks, the fall of the cage at first is quicker than that of the spring-supported weight, and the catches close ; with the model the action appears to be instantaneous.

The disconnecting hook was patented by Mr. Calow in 1859 and 1862, and is similar to Whitelaw's (*see* No. 111), the jaws being kept expanded in the socket by the action of a spring, which is overcome when external projections from these jaws encounter a collar in the head frame. M.1401.

138. MODEL OF CAGE WITH SAFETY CATCHES AND DISCONNECTING HOOK. (Scale 1 : 8.) Contributed by J. K. Hampshire, Esq., 1862.

The arrangements shown were patented by Mr. Hampshire in 1862. The cage has two decks and a projecting iron hood ; it is guided by four channel slippers sliding on timber guides, which also receive the grip of the safety catches. The catches consist of a pair of levers on each side of the guides, and are forced on by plate springs arranged under the upper deck. The cage is lifted by extensions of the catch levers, which are curved so as to form hooks which engage with lugs on the cage, so that the lifting pull is directly met.

The disconnecting hook consists of a pair of cross levers, which, by the weight of the cage, are closed together round the end link of the hauling rope ; the upper ends of the levers are prolonged beyond the jaws as horns which are wedged open by the top of the frame when overwinding occurs, the jaws are thus opened and the rope released, the safety gear then being relied upon to retain the cage. M.1384.

139. MODEL OF CAGE WITH SAFETY CATCHES AND DISCONNECTING HOOK. (Scale 1 : 12.) Contributed by John Whitelaw, Esq., 1862.

This is a light metal cage, working in timber guides on to which spring-moved safety catches press and close should the rope break ; the grippers of the catches have enlarged roughened faces. The weight of the cage is taken by the stops of the catch-levers ; the closing spring is a bar supported in its middle by a bracket inside the hood.

The disconnecting hood consists of two claws forced asunder by a spring between them ; these are enclosed by a socket which has internal grooves, and is attached to the cage. When overwinding occurs the claws are drawn through a ring fixed in the head timbers, which closes the claws together, and so releases the cage, which is then retained by the safety catches. M.1389.

140. MODELS OF CAGES WITH WIRE GUIDES AND SAFETY CATCHES. (Scale 1 : 6.) Made by J. P Harper, Esq., 1869.

Two examples are shown for a 13·5 ft. shaft, one a single cage with two wire rope guides, the other a two-decked cage to carry four wagons, controlled by four wire guides. In the two-decked cage the guide ropes are each enclosed by two slippers attached to the sides of the cage, but the safety catches are applied only to two of the wire ropes, which are diagonally opposite. The pull of the hoisting rope is taken by four chains attached to the top of the cage, but a portion of the pull is also taken by a bar connected with two plungers in spring boxes ; should the hoisting rope fail, the spring will force the plungers downward and so close the nipping levers on to the rope guides. In the single cage the whole of the weight is taken by the beam that applies the safety catches ; shoulders on the plungers preventing any over-compression of the springs. A model (scale 1 : 2) of the catches for the rope is also shown. M.1388. 20,789 L.S.

141. MODEL OF PIT-HEAD GEAR WITH CAGES AND DETACHING HOOK. (Scale 1 : 24.) Presented by E. Ormerod, Esq., 1880.

A pit-head frame, built up of timber, and a simple form of iron cage, with wire guides, are shown.

The detaching hook for the prevention of overwinding, was patented in 1867 and 1875 by Mr. Ormerod ; it acts by disconnecting the shackle from the rope, while at the same time supporting the cage in a bell-mouthed casting provided for the purpose on the pit-head framing.

The hook is a scissors arrangement of three plates pivoted on a central pin ; the upper ends of the plates are slotted and notched in such a way that the pin of the rope shackle in the normal position is firmly retained, accidental displacement being guarded against by a shearing pin passing through all three ; the lower ends of the plates are spread out and have slotted holes, through which passes the pin of the shackle attached to the cage. When overwinding occurs, and the hook is pulled into the fixed bell-mouth, the spread out ends are forced together, thereby shearing the pin and releasing the rope shackle, but, at the same time, opening the plates at the top, and causing the notched ends to overhang the bell-mouth, so as to prevent the descent. The holes in the lower end of the plates are so shaped that when the hook releases above, the lower shackle pin drops into a position that prevents the plates again closing.
M.1387. 20,812 L.S.

142. MODEL OF DISCONNECTING HOOK. (Scale 1 : 8.) Presented by J. King, Esq., 1875.

This form, patented by Mr. King in 1867, and subsequently improved, consists of two outside plates connected by a shackle with the top of the cage, and containing between them two jaws or opposite hooks, pinned together, which cross each other, and retain the rope shackle. Below the central pin they are extended so as to form levers that will open the jaw when overwinding occurs, and they are drawn through a fixed socket ; this opening causes the shoulders on the jaws to engage on the fixed socket which thus retain the load. A copper shearing pin prevents accidental disengagement. M.1402.

143. MODEL OF SAFETY GEAR. (Scale 1 : 16.) Presented by the Royal Commission on Accidents in Mines, 1886.

Two cam catches on a single horizontal shaft are employed ; on the shaft is a horizontal lever carrying a weight, the downward action of which is resisted by a vertical helical spring of less travel. If the rope breaks, the lever-weight at first falls less rapidly than the cage, and so applies the catches (*see* also No. 137).
M.1400. 21.017 L.S.

144. MODEL OF CAGE WITH DISCONNECTING HOOK. (Scale 1 : 6.)

The cage is of simple construction, but shows a longitudinal shaft with projecting ends which, when swung round, retains a wagon in position by its top.

The disconnecting hook, which was introduced by Messrs. Ramsey and Fisher, is of the disconnecting and sustaining type. It consists of two jaws that between them grip the shackle of the hauling rope ; these jaws are carried in a block to which they are hinged at their lower extremities, and are hooked at their upper outer edges, so that when opened to release the lifting rope in a case of overwinding, the hooks will lodge over the top edge of the socket fixed in the head framing, and so retain the cage. In ordinary work the jaws are kept closed by two side keys that fit between the jaws and the block, these keys have enlarged heads that project through the block. When overwinding occurs, the keys are forced downward so freeing the jaws, while they also act on the tails of the jaws so as to open them ; a central wedge also assists in opening the jaws, as it is pulled up by two side plates connected by shearing pins with the rope. To prevent an accidental release, two metal pins are provided that must be sheared by the keys before the latter can move, these affording a resistance that only actual overwinding would overcome. M.1390. 20,790 L.S.

145. MODEL OF PROPOSED SAFETY GEAR. (Scale 1 : 8.)

This is a cage with four pairs of catches arranged to cut into the timber guides ; the weight of the load is taken directly by the lifting chains, while the cage is lifted by lugs, resting on the platform. The idea of the inventor was to use the weight of the load to move the catches should the rope break ; but as the cage and load fall at practically the same rate, the catches are not applied, and without springs the arrangement is useless, a fact that the model will clearly demonstrate. M.1385.

146. MODEL OF DETACHING HOOK. (Scale 1 : 3.) Made by Messrs. T. Walker & Son. Received 1897.

The model is fitted with framing, and an overhead sheave to indicate the pit-head gear and to support the experimental load, when the detaching gear releases it from the lifting rope. The hook consists of a pair of hinged jaws which can be closed together round the pin of a shackle permanently attached to the winding rope ; the jaws are kept closed by a collar beneath them. When overwinding occurs, the detaching hook is drawn up through a conical socket secured to the framing, but the socket, being too small to allow the collar of the hook to pass, is drawn down the hook, and by its action on the lower end of the jaws, opens them, so releasing the shackle and preventing the breakage or straining of the rope. The expanding jaws of the hook are, however, too wide to pass through the fixed socket and so are retained, notches on them giving further security by engaging over a ring on the upper edge of the socket. To prevent the retaining collar from accidentally dropping, and so releasing the hook, two metal pins are inserted, each of which must be separately sheared by the collar before it can drop, so that only by considerable force can the position of the collar be altered. M.2967. 20,786 L.S.

147. MODEL OF DISCONNECTING HOOK. (Scale 1 : 10.) Presented by Messrs. Joseph Wright & Co., 1904.

This is a modification of King's original detaching hook for the prevention of overwinding (*see* No. 142) ; it is arranged on the upper portion of a wooden pit frame so that its action can be shown.

The improvements, patented in 1896 and 1900 by Messrs. E. G. Weddell, J. G. Chamberlain, and R. Player, consist in cutting away the two outer fixed plates at the jaws on opposite sides and thickening up the inner scissors-like plate so as to be flush, thus giving increased bearing area to the shackle. They also provide the scissors plates with two pairs of catches. Should overwinding occur, one pair of catches begins to project simultaneously with the opening

of the scissors plates; should the overwind be complete the second pair come into operation and prevent the shock and damage which would otherwise ensue in falling on to the catch plate. The small shackle shown is used, in the hole provided, to lift the catches off the catch plate and lower the cage to the pit bank so as to allow the shackle of the winding rope to be again inserted.

M.3373.

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148. MODEL OF MINE-HEAD FRAME. (Scale 1 : 24.) Made in the Museum, 1919. Plate II., No. 4.

This represents the Australian vertical mine-head frame, locally known on the different mining fields as a "poppet head."

Various forms of mine-head frames are used, but they may be classified under two types: the gallows, and the pyramidal types. This latter form is the one shown in the model and is that usually adopted on the Australian Continent; it requires, as will be noted, long straight timber. The gallows type of frame is preferred where timber in short lengths only is available. The main portions of the frame work is usually constructed of jarrah or karri well bolted together; the joints are further strengthened with gusset plates fixed by coach screws. The lighter portion of the structure, *viz.*, flooring, &c., are of Oregon pine.

Dimensions: height, 89 ft.; base, 48 ft.; the first landing floor (brace), 24 ft. from the surface. The sky shaft shows two hauling compartments each 2 ft. 4 in. by 4 ft. 2 in. A ladder and pump way is shown where the ladder projects above the surface; the size of this compartment is 4 ft. 6 in. by 4 ft. 2 in. Other details are according to scale. Inv. 1919—225. S.M. 1139-40.

149. MODEL OF PIT-HEAD FRAME. (Scale 1 : 48.) Made from particulars supplied by the Glengarnock Iron and Steel Co., Ltd., 1911.

Timber pit-head frames (*see* No. 132) have now been displaced largely in highly industrialized countries by those of steel or reinforced concrete. The model represents two examples in mild steel made by the Glengarnock Co. for Binley Colliery, Wolston, Coventry, in 1907 and 1910 respectively. These shafts are 16 ft. diameter by 300 yd. deep.

The frames are constructed almost wholly of rolled (principally girder) sections, the advantages of which as compared with the more usual lattice girder construction are that, although less economical in material, the frame is, owing to the simplicity of construction, cheaper, and also is more easily painted. The uprights and back stays, as well as other main members, are of 16 in. by 6 in. joists; horizontal members and cross bracing are of 12 in. by 6 in., 10 in. by 5 in., and 6 in. by 5 in. joists, the connections being made by gusset plates and rivets. The space left without cross bracing is for the pit bank operations. A ladder gives access from here to the top platform, where are the pulleys, 16 ft. diameter, the weight of which and the pull due to the winding rope are transmitted to the frame by vertical and inclined staying. The platform is covered with chequered plates, and is protected by a light railing. There are two single-decked cages (not shown), each guided by four ropes 4·25 in. circumference, and weighing 2 tons each. These are hung from cross girders on the top of the frame, and kept taut by weights at the bottom of the shaft; the ropes of one cage are arranged so as not to foul the adjoining ones of the other cage.

The winding ropes are 3·75 in. circumference, not tapered, and each weighs 1 ton. Each cage weighs 1·65 tons, and raises two tubs which, loaded with coal, weigh 1·7 tons, so that the total load to be lifted is 4·35 tons. The winding engines are of the trunk type, having cylinders 27 in. diameter by 5 ft. stroke with Corliss valve gear, steam foot brake and steam reverser; they are supplied with steam at a pressure of 180 lb. per sq. in. The average speed of winding is 40 ft. per second. M.3969.

150. FLAT DRAWING CHAINS. Received 1865.

These chains were introduced into South Staffordshire collieries in 1810 by Benjamin Edge, of Coalport; they were displaced gradually by wire ropes after 1850.

The "flat rivet" chain is made of two flat iron links with through pins riveted into side plates, alternating with three similar flat iron links looped over the same pins. Weight, 21 lb. per yd.; breaking load, 21·5 tons.

The "wood and stub" chain has three long alternating with three short links to keep them apart; the long links are filled with hard wood, retained by nails at the edges. Of many sizes made, two are shown; the larger weighs 28 lb. per yd., breaking load, 30 tons; the smaller, 10 lb. per yd., breaking load, 10·75 tons. M.3770.

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151. MODEL OF MAN-ENGINE. (Scale 1 : 24.) Made by T. B. Jordan, Esq., 1842. Plate II., No. 3.

The man-engine is a machine introduced in the Harz in 1833, and since used on the Continent and in Cornwall to a considerable extent, as a means for assisting the miners in ascending, and in some mines descending, the shaft in place of ladders. The earlier form with two rods is less used than the single rod arrangement.

This model represents an engine with two rods connected to a pair of reversed T-bobs, which mutually counterbalance. These rods are rocked from a crank driven by an engine or water-wheel and are guided at intervals by flanged rollers, while on their fronts at distances of 10 ft. are projecting platforms, about 14 in. square, connected on the outside by a handrail. To ascend, the miner steps on to a platform and when it has reached the top of its travel steps on to a platform on the adjacent rod, which is then at the bottom of its stroke and will take him up the next stage, when he steps on to another platform on the first rod, and so on.

The first double-rod man-engine built in Cornwall was erected in 1843 and reached a depth of 1,740 ft. It was worked by a steam engine of 36 in. cylinder diameter by 6 ft. stroke, making 15 revs. per minute and driving the rods by a crank making 3·5 revs. per minute with a stroke of 10 ft. The men were lifted at a speed of 73 ft. per minute, and 24 minutes were requisite for the entire journey. M.1398. 21,049 L.S.

152. MODEL OF GERMAN MAN-ENGINE. (Scale 1 : 16.)

This represents a double-rod engine erected near Freiberg in 1857. The rods are 8·5 in. sq., have a stroke of 56 in., and are guided by wrought-iron bars bolted on them and working in fixed plates secured to cross timbers placed at intervals of 48 ft.; stops are fixed to the backs of the rods at intervals of 18 ft. to retain them should the mechanism fail. The rods are connected together at intervals by chains passing over sheaves, and thus counterbalance each other; the bearings for these sheaves completely obstruct the rods and have to be passed by the men on fixed ladders. The small platforms shown have no hand-rail, but a handle is fixed above each at a convenient level.

M.2825. 21,049 L.S.

153. MODEL OF CORNISH MAN-ENGINE. (Scale 1 : 8.) Received 1859. Plate II., No. 3.

This, the first single-rod man-engine, was erected at the Fowey Consols Mines, Cornwall, in 1851; several other examples have since been constructed. It was with one of these, at the Levant Mine, that a fatal accident happened in 1919.

The rod extends vertically from the surface to a depth of 1,680 ft., and is driven by an overshot water-wheel 30 ft. diameter by 6 ft. face, making three revs. per minute. A crank on the axle of the wheel is directly connected by a bob by which the rod is given a stroke of 12 ft. The rod is 8 in. sq. and built up of timbers 36 ft. in length, butting together and connected by fish-plates,

each 12ft. long. The rod platforms are 12 in. sq., with handles of 0·75 in. round iron 2 ft. long fixed 4 ft. above them ; similar handles are placed at the stationary platforms upon which the men rest during the alternate strokes. The weight of the rod is counterbalanced by three bobs, two of which are underground. M.1397. 21,049 L.S.

VENTILATING.

154. MODEL OF VENTILATING FURNACE AT HETTON COLLIERY. (Scale 1 : 24.)

This model represents a furnace of the largest type, as formerly used in Durham, and is so arranged that the amount of grate surface in use may be varied according to the requirements of ventilation.

The furnace stands between the return air-way and the upcast shaft in a chamber opened out of the solid coal, lined with ordinary brick and with a segmental arched roof. The firegrate is level, measuring 25 ft. by 5 ft., and has side walls and a semi-circular arched roof of firebrick ; the large openings at the ends of the bed are for the passage of the foul air over the fire. Stoking is done through four pairs of side doors over which are four holes for the admission of air above the fire ; the stoking space is 7 ft. wide on this side, and behind are two recesses 4 ft. sq., for storing coal ; the other side of the furnace is 2 ft. from the wall of the chamber. The upcast shaft is 9 ft. diameter, lined with brick-work. Two furnaces in connection with this pit passed a current of 104,000 cub.ft. of air per minute at a pressure of 1 in. of water (5·2 lb. per sq. ft.).

Where there is any danger of explosion resulting from fire-damp in the foul air, it is delivered by an inclined or " dumb " drift at a point some distance up the upcast, the fire being fed with fresh air from the downcast ; this practice is general where furnaces are still in vogue. M.2618. 21,020 L.S.

155. MODEL OF SOUTH WALES COLLIERY VENTILATING FURNACE. (Scale 1 : 24.) Presented by Messrs. Vivian & Sons, 1856.

This is a type of underground furnace once very common ; it consists of a plain rectangular firegrate placed at the lower end of a short drift or level which rises at an angle of about 13 deg. towards the upcast shaft. The drift, being in the coal seam, is lined with brick ; the furnace is covered by an inner lining of fire-brick leaving a space between the two, divided by arched diaphragms to form air passages to keep the outer arch cool. To obtain more complete combustion of the smoke and gases from the furnace, a transverse perforated pipe is introduced just behind it, and is supplied with air by a funnel-mouthed pipe set to meet the draught. The upcast shaft is four-sided in section, the sides being formed by two pairs of arcs of different radii. M.2617. 21,066 L.S.

156. MODEL OF VENTILATING FURNACE. (Scale 1 : 12.) Presented by J. M. Paull, Esq., 1858.

This furnace was patented by Mr. Paull in 1857, but never came into extensive use ; it is intended for use in fiery collieries where the foul air must not come into contact with the flame.

The firegrate is inclosed in a square shaft-like chamber with an arched roof from which a chimney extends into the upcast shaft. A number of copper tubes, the greater number horizontal, but the lower ones inclined, are placed across the furnace. On the one side these communicate with the return air-way and on the other with the upcast, so that a current of air is established from left to right. The products of combustion are only brought into contact with the foul air at the top of the chimney where the temperature is considerably reduced. The fire is fed with air direct from the downcast. The patentee recommended that the tubes should be at least 6 ft. long, increasing in diameter from the intake to the outlet ; the diameters recommended were 6 to 9 in.

M.2619. 20,021 L.S.

157. MODEL OF MINE WITH DOUBLE VENTILATION. (Scale 1 : 792.) Contributed by W. Oliver, Esq., 1842.

This model of a coal mine worked on the "board and pillar" system (*see* No. 98), illustrates Mr. John Buddle's system of double or compound ventilation for fiery collieries.

The seam is an inclined one, dislocated by a downthrow fault near the centre; the shafts are sunk at the lowest point, and the workings are carried on towards the rise. The workings on either side of the fault are distinct, but are put in communication by a pair of drifts driven through the fault.

The ventilating furnace is at a short distance from the upcast shaft, in the centre of a rectangular block bounded by two parallel inclined drifts and two transverse horizontal ones; the return currents of air are controlled by six doors, marked A to F, in these four drifts. The currents of air from the districts D and G pass over the furnace, while those from E and F, being fiery, are passed to the bottom of the upcast by a dumb furnace so as to obviate direct contact with the fire. If the air in D becomes fiery it is thrown on to the dumb furnace by opening the doors A and B; by suitably arranging the doors other conditions can be met.

(*See* Trans. Nat. Hist. Soc. Northumberland, II., 309). M.1394. 21,065 L.S.

158. MODEL OF SELF-CLOSING DOOR FOR AIRWAYS. (Scale 1 : 16.) Contributed by T. Heaton, Esq., 1865.

The current of ventilating air sent into the downcast would pass directly to the upcast shaft were it not for doors placed across the roadways, for by these the air is caused to circulate in sections round the working faces. Important doors, where there is heavy traffic, are, as a rule, opened and shut by boys stationed at them.

The model shows an arrangement, patented by Mr. Heaton in 1856, whereby the wagons in a coal mine on their approach open the door, which after their passage again closes. The doors are of the sliding type carried on inclined rails above, so that they have a natural tendency to run together and so stop the passage. On either side of the doorway are two long levers pivoted to the side of the working but having their free ends inserted in the doors. The front of the wagon is fitted with a metal loop that, acting as a wedge, separates the levers and opens the doors, retaining them open until the wagon has passed.

M.2620. 21,027 L.S.

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159. SHAW'S GAS TESTER. Received 1901.

This is an apparatus patented by Mr. Thomas Shaw, of Philadelphia, in 1887-88, for rapidly estimating the amount of deleterious gas present in the air of a mine. This it accomplishes by determining the volume of methane, or other combustible gas, that it is necessary to add to a sample of the mine air to render it explosive; these samples are collected from various parts of the mine in india-rubber bags filled by means of a diaphragm pump.

The testing apparatus consists of two single-acting pumps, one of which is the larger and is for pumping mine air from a sample bag, while the smaller one is for drawing combustible gas from a holder. These pumps are arranged under a graduated beam, which can be oscillated by a crank motion; but the stroke of the gas pump is adjustable, owing to the distance of this pump from the beam fulcrum being variable. The graduations on the beam are so marked that they directly give the percentage which the gas from the smaller pump forms of the total volume discharged by the two pumps. Through these pumps the air and gas is sent, by mechanically moved valves, into a mixing valve and then into a chamber provided with a firing gas jet at an orifice near the middle while one end is closed with a cap which, when displaced by an explosion, strikes a gong.

When testing a sample from the mine the position of the smaller pump is successively varied until an explosive mixture is obtained, when, from the readings on the beam the percentage of added gas is ascertained; from corresponding results obtained with pure atmospheric air the percentage of "fire-damp" in the mine atmosphere is determined by subtraction.

The apparatus is similarly used for testing for "choke-damp," or carbon dioxide, the gas cylinder being, however, thrown out of action by sliding it

under the fulcrum. A quantity of mine gas is then pumped through lime water until it attains a standard degree of turbidity, usually that obtained by passing through it a half cylinder-full of a 1 per cent. mixture of carbon dioxide and air. The amount of mine air necessary to give this degree of turbidity is read off from a graduated scale attached to the piston of this pump. M.3166.

LIGHTING.

160. MINERS' LIGHTING APPLIANCES. Plate II., No. 5.

The examples in the Museum illustrating the development of lighting in mines number upwards of 100. To obviate separate entries in this Catalogue they are dealt with collectively, although in the Museum each object has a separate label. Lighting appliances of general application will be found in other sections of the Museum.

The open oil lamp was successfully adopted for miners' use at a very early period. This, the spout lamp, and tallow candles in holders, are still common, especially in metalliferous mines. Early in the 18th century it was found that the air of certain coal-mines contained gas which caused explosions with naked lights. The light of sparks from flint and steel in the steel mill was possible in such places, but gave a miserable light, and was extremely costly. It was not till 1815, when Sir Humphry Davy's attention was directed to the subject, that a practical safety lamp was devised. Davy found that small tubes, perforated metal or wire gauze, will so cool a flame attempting to pass it as to prevent the ignition of inflammable gas on the other side; this principle he embodied in the Davy lamp, and it has been relied upon for the security of all safety lamps up to the present. George Stephenson was independently experimenting at the same time with a lamp in which the air was admitted to the flame through small tubes; this he developed into a successful type. Owing to the low illuminating power of the Davy, Dr. W. R. Clanny in 1839 replaced the lower part of the gauze by glass, above which the feed air enters. In 1840, as an outcome of an inquiry in Belgium, Mr. J. Mueseler independently brought out his lamp which resembles the Clanny externally, but has a conical metal chimney supported by a gauze diaphragm inside the gauze case; this led also to the invention of the Boty (1844) and the Eloin (1846), in both of which the air was fed in below the glass. Safety lamps were made compulsory in Belgium in fiery mines in 1851; of these, in 1864, the Mueseler alone was permitted. As it was found that the proportions of the lamp affected its safety, these have been fixed by law in Belgium since 1876.

Davy had pointed out that if the flame impinges on the gauze in draughts, &c., or if the fire damp burns inside the case and the gauze cannot conduct away the heat rapidly enough, flame will eventually pass. Experience had shown this to be the case prior to 1835. To obviate the danger, as the velocity of ventilating currents steadily increased, shields were devised. The experiments carried out by the Royal Commission on Accidents in Mines in 1879-1886 showed that many lamps then relied on were unsafe owing to the absence of shields or bonnets and drew attention also to many new lamps, *e.g.*, the Gray (1868), with tubular feed, subsequently developed into the Ashworth-Hepplewhite-Gray testing lamp and the Marsaut (1883), with double conical outlet gauzes. The latter was the outcome of experiments, which showed that the volume of a lamp should be small; that the height and diameter of the glass should be reduced as far as possible; that the outlet gauzes should be conical, and that a shield or bonnet for this gauze were necessary. Practical considerations necessitate that weight should be kept down; that holes and gauzes should not be quickly choked by dust, and that the parts should be few and admit of being quickly cleaned, and assembled. The latter operations, as well as filling and lighting, must be done each time a lamp is used, and necessitate considerable outlay for lamp rooms and lamp trimmers. As many as 20 per cent. of the lamps are sometimes accidentally extinguished during a shift; to obviate bringing them to special lamp stations, relighting devices are employed, such as Wolf's fulminating strip or the high tension electric spark in conjunction with a benzene lamp.

The difficult problem of preventing the miner risking his life and those of his comrades by opening his lamp while at work has led to the invention of numerous locking devices. In the order of time they are the screw; the padlock

the lead plug or rivet and various forms of mechanically, pneumatically, and magnetically controlled bolts. The lead rivet is by far the commonest; the lamp can be opened, however, but not without detection. Another method is to ensure that the act of opening the lamp shall put out the flame by some form of extinguisher of which the protector lamp is the best known example.

The incandescent electric lamp has been adopted on the mine roads, &c., but for working faces generally the system is hardly flexible enough. The portable storage battery lamp has been used, but its weight and cost are, so far, great drawbacks. The difficulties connected with the use of acetylene for mining lamps have been overcome, and such lamps, which have advantages over oil, are successfully used.

For detecting the presence of fire-damp the bluish aureole it imparts to a flame is observed. Ordinary lamps, especially the Gray, give reliable indications when 2·5 per cent. is present, but alcohol is relied upon for smaller quantities, and lamps employing this have been worked out by Pieler, Chesneau, Stokes, and others. M.2826-2893, &c.
21,055 to 21,058, 21,063 L.S. S.M.722 to 726.

MODELS OF MINES IN GENERAL.

161. MODEL OF SAXON MINE IN THE 18TH CENTURY. (Scale of workings and details 1 : 36.)

The three portions show vertical sections of the shaft and workings of a lead-ore mine. The shaft has a lined way for the skips, a ladder-way for the miners, and also contains two sets of pump rods, with the early pumps and wooden pipes, or "trees," that rendered pumping in stages necessary. These pumps were driven by an overshot waterwheel on the surface, vertically above them.

The model shows two methods of winning the ore, in one case by "overhand-stoping" in which the refuse material, if sufficient, forms the working platform and is supported over the levels by timbers; in the other, or "underhand-stoping" system, the refuse is supported by timbers over the workers; in both plans the area of the working face is increased by the stepped arrangement adopted. The employment of windlasses in small shafts is shown, also the planked way over which the boxes were slid before the general introduction of rails and wheeled trucks. M.2823-4. 21,071 L.S.

162. PHOTOGRAPH OF DRAWING OF THE QUICKSILVER MINE OF ALMADEN. Presented by the Royal School of Mines, Madrid, 1876.

This shows a plan and section of this celebrated mine as it appeared in 1796. The mine, which has been worked since 1564, is situated on the northern slope of the Sierra Morena. There are three principal deposits of cinnabar-impregnated sandstone extending for a distance of about 600 ft. along the strike; the dip is nearly vertical. The total useful thickness is reckoned to be 40 ft. The rock yields about 10 per cent. of mercury. E.1876.

163. MODEL OF IRONSTONE MINE. (Scale 1 : 600.) Presented by Messrs. J. & J. W. Pease & Co., 1862.

This shows the method of working Cleveland ironstone at Upleatham (*see* No. 110). As shown in an adjacent drawing of the strata, the bed of ore is 12-14 ft. thick divided by a parting of iron pyrites. The lower part of the bed only is worked; this is done by driving headways 9 ft. wide and 90 ft. apart; from them at intervals of 30 ft. cross levels 15 ft. wide are excavated, thus giving a series of pillars 90 ft. long by 30 ft wide. These are finally removed with a loss of only 10 per cent. of their contents, or a total loss of 7·5 per cent. M.1409.

164. MODEL OF DOLCOATH MINE. (Scale 1 : 576.) Made by T. B. Jordan, Esq., 1839.

This shows the surface arrangements and a vertical section of this extensive tin and copper mine at Camborne as it appeared in the year 1839. The red wood represents granite and the white the clay slate of Cornwall; the lode is shown by the black layers.

For a detailed account of this mine, *see* Sopwith—Account of the Museum of Economic Geology, 1843, 62. M.2786. 20,885 L.S.

165. MODEL OF HOLMBUSH MINE, CORNWALL. (Scale 1 : 720.) Made by T. B. Jordan, Esq., 1865.

This model follows the system employed in drawing mine plans, the whole of the excavations made, whether shafts, levels, or lode removed, being represented in colours, while the untouched surrounding material is left blank; the reverse method of treatment is represented in the model of Dolcoath mine, where the excavations are represented in the more natural though less convenient manner.

In the model the sections by horizontal planes at vertical intervals of 60 ft. are secured to brass frames, upon which are stretched cross wires representing the lines of northing and easting as usually drawn on mine plans.

The workings on each lode are distinguished by special colours as follows:— Holmbush lode, red; flapjack lode, yellow; lead lode, blue; cross courses, green. M.1557.

166. MODEL OF MEXICAN SILVER MINE. (Scale about 1 : 20.) Presented by T. G. Hopkins, Esq., 1913.

This is a native representation of the operations in a silver lead mine in the State of Oaxaca, Mexico, prior to 1850.

The model may be taken to represent a "bonanza" or large body of ore, the boundary of which is indicated; an attempt is made to show the stringers of galena running through the main body of veinstuff. No timbering is used but a pillar of veinstuff is left to support the excavation.

In the background is a timber platform or "sollar" put up to facilitate stoping. There is the characteristic notched ladder and also the "lanternilla" or lantern of the Mexican. The "tenateros" carrying ore in leathern sacks on their backs represent the primitive method of transport. In the foreground double-handed drilling is shown and a mine official is examining samples of ore. M.4206.

167. MODEL OF JAPANESE MINE. (Scale of details 1 : 30.) Presented by J G. H. Godfrey, Esq., 1877.

This is a native model illustrating the method of mining for gold and silver in Sado Island. The entrance to the mine is by a timbered passage or adit in the side of the mountain; the level and shafts are timbered with round timbers and packing. Notched bamboos are used as ladders, but many of the miners are working on light suspended platforms. The removal of the material is done in packs carried on the back. M.2822. 20,810 L.S.

168. MODELS OF TYROLESE METHODS OF SALT MINING. (Scale 1 : 4,800.) Made by Bergmeister T. G. Ramsauer, 1858.

These mines are situated in the Duchy of Salzburg. The rock consists of a mixture of clay with more or less salt, interspersed with veins of gypsum. Sections are shown on the sides of each model, and the different levels are represented on superposed plates of glass.

The working of these mines has been carried on from very early times, the present system being introduced in 1311. A series of levels at heights of about 120 ft. are driven into the hill side, and small branch levels are driven from these obliquely into the workings. The mouth of the branch level is dammed up and the whole chamber filled with fresh water, which is allowed to remain in the workings till it contains 27 per cent. of salts (or 25 per cent. of Na Cl); it is then run off to the boiling houses, which are sometimes 10 miles distant. For driving the levels, sinking winzes, &c., jets of water under pressure are utilised, a method introduced by Herr Ramsauer in 1841. M.2649.

169. MODEL OF CLUNES GOLD MINE (1858). (Scale of details 1 : 48.) Presented by the Port Phillip and Colonial Gold Mining Co., 1865.

Clunes, in the district of Melbourne, is the locality where, in 1851, gold was first discovered in Victoria, and it was at this mine in 1857 that the milling of gold quartz was first practised in Australia. The model shows, in a general way, sections of the ground and workings, as well as the original arrangements at the surface for separating the gold from the quartz, which, as this plant inaugurated the system of treatment generally adopted throughout the continent, possesses exceptional interest.

The sections indicate four main lodes running nearly N. and S. but dipping steeply, as well as a number of smaller veins or leaders of varying inclination and thickness, while the surface shows how, owing to the lodes or quartz veins being harder than the enclosing rocks, the outcrops appear in a ridge projecting above the general level.

The preliminary operations in opening the mine consisted, as is still usual, in sinking small shafts, the mouths of which were built up by logs, so as to form tips and also to carry the windlasses by which the skips were raised (*see* No. 52). When the value of the lodes had thus been ascertained, a deep main shaft was sunk, from which, at vertical distances of 60 or 100 ft., cross cuts, or tunnels, at right angles to the run of the lodes, were driven. When the lodes were reached levels were driven along them and the veinstuff removed by stoping.

The pit-head frame over the main shaft was arranged for winding with a flat rope and a skip running in guides ; the work was done by a single cylinder engine and a multitubular boiler, which also actuated two lines of pump rods in the shaft.

On arriving at the surface the quartz was tipped into wagons and, if necessary, calcined in a kiln to render it sufficiently friable, but this practice was superseded in 1865 by the use of a stonebreaker. The quartz was then conveyed by an incline to the hoppers at the back of the stamp battery, from which it was fed to the stamps by shoots having a jolting motion. Originally there were only 20 stamp heads, but in 1859 these were increased to 44 ; they were in four batteries, and were similar in construction to those shown in No. 204. Two of the batteries were driven by Jordan's single cylinder engine (*see* Catalogue, Part I.), taking steam from a water-tube boiler ; another by a semi-portable engine and boiler and one by a horizontal engine on a cylindrical return-flue boiler. The fuel used throughout was wood, for preparing which a circular saw was provided.

The material from the mortar boxes was cleaned up at intervals in cradles (*see* No. 225), while that discharged through the screens passed first over a " well " or shallow trough containing mercury, and then over a series of inclined tables having low steps covered with blankets. This system of collection was adhered to throughout the Clunes district, but elsewhere has been superseded by the usual amalgamated plates. The auriferous sand entangled in the blankets was removed at frequent intervals by washing the blankets in a tub of water and collecting the gold by barrel amalgamation and a shaking frame, or even by hand washing ; any pyritic tailings from the barrels were afterwards separately treated by finely grinding them with mercury under edge runners. The amalgam was filtered by squeezing through buckskin, and the solid remainder treated by distillation in the pots shown set in the brickwork of the return flue boiler. The gold was taken to Melbourne on a pack-horse, escorted by mounted police, for whom a station was erected at the mine. M.1558. 25,224 L.S.

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170. GEOLOGICAL MODEL OF THE NORTH STAFFORDSHIRE COALFIELD. (Vertical and horizontal scale 6 in. to 1 mile, or 1 : 10,560.) Made from particulars supplied by the Geological Survey, 1914.

This particular coalfield was chosen for illustration because all the features of importance to a student are comprised within a limited area.

On the horizontal sheet of glass which forms the cover of the model are represented (*see* index) a few topographical features, such as means of communication, populous areas, &c., together with the out-crops of various beds and the main geological faults.

A series of geological sections at equal distances across the model are represented in colour by vertical glass sheets, and these are tied up with one another by the colouring on the floor of the case. A further section along the Biddulph trough is represented similarly by glass sheets. An index showing what each colour represents is given.

A pamphlet descriptive of the geology of the area is in preparation by the Geological Survey. Inv. 1914—687. S.M.605.

SURFACE ARRANGEMENTS AND COAL TIPS.

171. MODEL OF THE SURFACE MACHINERY OF A COAL-PIT. (Scale 1 : 24.) Presented by John Wales, Esq., 1858.

This model represents the arrangements formerly adopted in the large collieries of Durham and Northumberland.

A is a vertical, single cylinder, high pressure, direct acting winding engine. Above the cylinder is the crank-shaft on which are the fly-wheel and the drums with the flat rope used for winding, as well as a smaller conical drum which raises the small coal to the screens L by means of a chain. The piston rod is guided by Watt's parallel motion, and the cylinder is supported on a cast-iron column at a considerable height above the ground. On the fly-wheel is a strap brake applied by the engineman's foot. The exhaust pipe is carried through the cistern from which the feed pump draws the supply for the boiler.

B are two Lancashire boilers each 30 ft. long by 5 ft. diameter.

CC is the pit-top—a timber platform carried on columns 16 ft. above the ground in order to facilitate screening and loading. The " keps " or catches for the cage are nearly vertical wrought iron bars, two on each side of a cage-way ; they are fixed to horizontal bars which, by a single rotation from a handle, move them in or out of the cage-way—a device still fairly common. The platform is covered with cast-iron plates to make a smooth surface on which to manipulate the tram wagons.

DD are double-decked cages formed of three wooden platforms kept at a fixed distance apart by wrought-iron struts. Catches, attached to the roof of each deck, lock the wagons on the cage.

E is a water balance for bringing each deck of the cage in turn to the floor level of the bottom of the pit. It consists of two vertical cylinders communicating with one another in which work pistons attached to platforms upon which the cages rest. The pistons are further counterbalanced by weights so that either platform of the cage may be brought to the floor level without the help of the winding engine at the surface.

FF are tipplers or cradles ; these are wrought-iron frames mounted on trunnions so that when a full wagon is run on, it overbalances and is emptied, being then readily brought back to an upright position. A hinged flap on the top prevents premature discharge and undue breakage of the coal. In tipping, the long tail of the latch strikes against a projecting wooden block at the head of the screen.

GG are tram wagons or " tubs " made with wood, bound with iron, and each carrying about 8 cwt.

HH are chaldron wagons (*i.e.*, having a capacity of 53 cwt.) for surface transport ; they are of a type which has survived from the time when horses were employed for haulage, but are now, except for local traffic, replaced by larger 6-ton wagons.

II are screens, consisting of rectangular riddles, 18 ft. long by 6 ft. broad, with parallel iron bars 0·625 in. apart, and set at an angle of about 34 deg. The round coal is discharged directly into railway wagons while the small coal is collected in hoppers communicating with K.

J is a stage on which is thrown the shale, &c., picked from the coal while it is on the screen and in the wagon. When a quantity has accumulated the sliding doors are opened and it is shot into wagons which remove it to the spoil-bank.

K is a box-wagon by which the small coal from the hoppers is carried up an inclined plane to the screens L. The wagon is counterbalanced, and is hauled by the chain from the winding engine A.

L are screens for the small coal, which makes three sizes, " nuts," " seconds," and " duff " or " slack," which are discharged through the shoots M, N, and O ; the slack, when sufficiently clean, is used for making coke or patent fuel.

The above distinguishing letters correspond with those on the engraved plate attached to the model. M.2642. 21,464 L.S.

172. MODEL OF APPARATUS FOR SHIPPING COAL. (Scale 1 : 20.) Presented by Messrs. Vivian & Sons, 1856.

This was constructed for loading Welsh steam coal, an operation which requires special arrangements to prevent breakage, the coal being very tender.

The wagon, which has a bottom door, is lowered bodily into the hold of the vessel by a platform slung by flat ropes from the four corners, and guided by slides fixed to the quay wall. The ropes run over pulleys on the top framing and are wound on drums on a shaft which has also on it two other drums on which coil in the opposite direction flat ropes attached to balance weights. The weight of the loaded wagon being in excess of the counterbalance, the platform descends, winding up the weights as it falls ; when the wagon is emptied the weighted ropes unwind from their drums and bring the platform back to its original level. The speeds are regulated by wrought-iron brake-straps working on two brake wheels geared to the drum shaft. M.2645. 21,047 L.S.

173. MODEL OF APPARATUS FOR SHIPPING COAL. (Scale 1 : 20.) Presented by Messrs. Vivian & Sons, 1856.

In this arrangement the coal is brought alongside the quay in wrought-iron boxes provided with hinged doors at the bottom held up by chains. Each box is slung from the end of a crane jib when in the vertical position, and is then lowered outwards over the quay wall into the hold of the vessel ; the weight of the jib is counterbalanced by a weight sliding in a box behind. The coal box can be raised or lowered independently of the jib by means of a geared windlass fixed on the ground ; the weight of the box is counterbalanced, and there is an arrangement for letting go the hinged doors. Strap-brakes are provided for controlling the motions. M.2646. 21,054 L.S.

174. MODEL OF COAL TIP WITH ANTI-BREAKAGE BOX. (Scale 1 : 12.) Lent by the Taff Vale Railway Co., 1896.

This model represents one of a large number of coal tips working in the Cardiff district and has special arrangements to avoid the breakage of some of the tender coals raised in South Wales.

The coal is brought in end-tipping wagons, running on a high level road, along which the empty wagons are afterwards returned. The full wagons run directly on to rails on a lift platform or cradle, which by a brake is allowed to sink to the height of a discharging shoot that receives the coal when the cradle is tipped. The weight of the cradle and empty wagon is more than counterbalanced by weighted chains, which, when the wagon is discharged, will restore the cradle to the higher level after the controlling brake has been released ; the work is entirely done by the weight of the descending coal.

From the shoot the coal may fall directly into the vessel, but generally is lowered by anti-breakage boxes which, when the bottom is reached, are opened and so deliver the coal without shock. The return of the empty boxes performed by a counterbalance weight, as with the cradle.

These tips are fitted with hydraulic tipping rams, for lifting the back end of the wagon or cradle when the shoot is discharging, from a low level line into a high ship. In such circumstances the anti-breakage box is worked by an independent hydraulic ram.

In the model a second and later form of anti-breakage box is also shown, but not in position. This larger box, known as the " Thomas-Bachelor " box, is so constructed that while remaining closed when suspended, it opens when an attached chain is tightened. When it has discharged, a counter-balance weight immediately lifts the box, which automatically closes ready to receive its next charge of coal; this quick-working box is in use at the Penarth Dock.

M.2959. 21,064 L.S.

175. MODEL OF COAL TIP. (Scale 1 : 16.) Lent by James Rigg, Esq., 1870.

This shows a form of tip for discharging coal from railway wagons into stores or the holds of coasting vessels and steam colliers. The object of this tip is, by using a projecting shoot, to avoid the fall and consequent injury of the coal, also to dispense with the employment of hydraulic or other power, by utilising gravity to cause both the forward and return motions.

The coal wagon has an end door for delivery, and is run into a strong shoot carried on trunnions. At the bottom of the shoot a spur quadrant is fixed, into which gears a pinion keyed to a shaft carrying a brake sheave. When a full wagon is home in the tippler, the shoot tends to tip forwards, and when the wagon is emptied, the tendency is to return to the horizontal position, control in all positions being secured by the strap brake provided.

M.2740. 21,051 L.S.

176. MODEL OF COAL TIP AND SCREENS. (Scale 1 : 16.) Lent by James Rigg, Esq., 1870.

This shows an arrangement for discharging coal from the " tubs " or " corves " as received from the pit shaft, and classifying it by screens prior to its delivery into the respective wagons. It is particularly designed to avoid breakage of the coal.

The tip consists of a shoot, which oscillates upon trunnions through an arc sufficient to permit of the coal from the partially inverted pit tub leaving it freely but gently, and distributing itself over the screen. The tip is so balanced that the weight of the loaded tub causes the forward motion, and when the coal has been delivered on to the screen a counterbalance gives the preponderance needful to cause its automatic return; the oscillation in both directions is controlled by a strap brake. The upper screen in this example consists of a series of fixed bars and the " round coal " passing over them is delivered to its wagon over a hinged door, while the " nuts " and " small " are separated by a lower shaking riddle oscillated by a hand lever.

M.2741. 21,052 L.S.

177. MODEL OF GRAVITY COAL TIPPLER. (Scale 1 : 8.) Lent by Messrs. Heenan and Froude, 1902.

This machine is for tipping the contents of pit trucks into railway wagons, or on to screening apparatus, simply by the weight of the coal discharged.

The tippler, patented in 1901 by Mr. C. E. R. Sams, consists of a skeleton horizontal drum, riveted up in steel, with three chambers through it, parallel with its axis and each provided with rails of the same gauge as the pit trucks; the chambers have also plated sides, from which two rails project so as to overhang the truck wheels and thus retain the truck when the tippler rotates. The drum can be locked in three positions, by a bolt engaging with three stops on the drum and controlled by a hand lever, and this lever also relieves two weighted strap brakes by which the speed of rotation is checked.

When a full truck is pushed into the drum it drives out an emptied one, and, then, upon the lever being pulled, its weight causes the drum to rotate, carrying with it also two emptied trucks, till it is retained by the next stop. The full truck in thus being turned through 120 deg. delivers its contents on to an inclined shoot immediately below the drum, so that there is but little fall to cause breakage of the coal. The discharging capacity is up to 10 trucks per minute.

M.3264.

ORE DRESSING.

The operations thus designated comprise all those required in the preparation of a mineral for the market. Such operations vary widely with the nature of the ore or mineral treated. Stone is reduced in size or dressed to shape simply; coal is either classed in sizes and hand-picked, or sized and the smaller classes washed; high grade ores are simply hand-picked selectively. In continental countries many classes are thus made, but in this country, South Africa, Australia and America, preliminary hand-picking and washing are generally dispensed with. In the case of most metalliferous ores, the treatment is of an elaborate nature, firstly because of their complexity, *i.e.*, more than one desired mineral is often present, and secondly because the mineral usually exists in a fine state of division. The processes are then as follows :—

Ore Reduction.—The object of this treatment is to bring the ore into pieces not larger than a prescribed bulk. It thus covers preliminary breaking by hand hammers and crushing by machines; the feature common to these appliances is that intense local pressure is exerted. For coarse crushing the jaw type of machine (*see* Nos. 180 to 183) is used, while for fine crushing rolls of many kinds, stamps (which are in reality an assemblage of drop hammers), and for finished crushing, ball and tube mills are employed. Of these the stamp battery (*see* Nos. 199 to 207) and, the tube mill (*see* No. 212) perform much the widest service. Concurrently with reduction sizing usually goes on.

Sizing.—Sizing appliances are employed to separate crushed material into particles of uniform bulk irrespective of other qualities. The usual appliance is a sieve, screen or "grizzly." Screens are often used in series, the number of classes produced being equal to the number of screens employed, together with a reject of lumps which are sent back for further reduction. The cylindrical screen or trommel, in spite of the small area that is doing work at any one instant, is most generally used for ores, although for coal, flat sieves, as they cause less breakage, are preferred. If the flat sieve is agitated in water, or if water is pulsated through it, the jigging machine is developed. If an upward current of water is made use of the pointed box classifier (*see* No. 219) is arrived at.

Mineral Concentration.—As its name implies, the aim of this treatment is to bring together one or more desired minerals out of a bulk of classified material. The methods adopted in the order of their present day importance are :—(*a*) motion in water; (*b*) surface adhesion and froth flotation; (*c*) magnetic attraction; (*d*) motion in air.

(*a*) Motion in water is the principle underlying by far the largest proportion of machines in use. The property made use of is the difference in density of the mineral particle sought and that of its gangue: this, if the particles are of uniform size, causes a great difference in the rate at which they precipitate through water. For example, two particles of equal size, one of galena (sp. gr. 7.5), and one of quartz (sp. gr. 2.6), experience nearly equal resistance from the water, while the galena is attracted downward with about three times the force that the quartz experiences. If, however, the size of the galena particle is further reduced, a point is reached when the two materials fall at the same rate. In the case cited, the relative sizes of equal falling particles

or " equivalents " is 4 : 1. If, then, an ore containing these two materials is classified so that no class includes grains of quartz four times as large as the smallest grain of galena, separation will be possible.

In machines such as keeves and jiggers, in which the particles interfere with each other and their fall is no longer free, a still greater latitude in the sizing is found to be permissible. When the particles have a free path through water in which to settle, the machine takes the form of a jigger or hutching box that in its earliest form consisted of a water tub in which a riddle containing ore was shaken. The particles settled to the bottom in the order of their densities, and the deposit was afterwards removed in horizontal layers. Material from 0·1 in. to 0·04 in. diameter can be successfully concentrated in this way.

If surface friction is employed in addition to assist in the separation, as when the pulverised mineral is carried by water over a rough inclined board upon which the mineral deposits in bands of decreasing richness, the " table " type of apparatus is arrived at ; the thin layer of deposited mineral is easily removed by scraping or flushing with water. By using an endless belt or a circular table, continuously acting machines of great capacity are thus constructed.

If the deposit is allowed to increase to a considerable thickness the table becomes a " buddle " from which the mineral or concentrate is removed by scraping after a deposit of several inches in depth has accumulated. In order that the surface of the deposit may be maintained smooth, mechanically-moved brushes are swept continuously over it ; thus the formation of furrows is avoided and the surface is kept " alive " and free from the heavier gangue.

(*b*) Surface adhesion and froth flotation.—The practical application of this increasingly important branch of concentration has made rapid strides only since 1905, although investigators have been at work upon it since 1860. The property made use of is the selective action that certain minerals, notably sulphides, exhibit for oily substances, whereby the particle acquires a film that resists wetting by water, but readily attaches to itself gaseous bubbles ; the addition of small quantities of acids and other substances produces, with agitation, frothing effects. Thus the specific gravity of the whole body is so lowered that it can rise to the surface of water (*see* No. 255). The underlying theory of the process is only imperfectly understood, however.

(*c*) Magnetic attraction as a means of concentration was of limited application until recently, when it was found that by increasing the intensity of the magnetic field and by specially shaping the pole pieces, minerals hitherto considered non-magnetic, or only feebly magnetic, were found to be susceptible of treatment. Machines can be classified accordingly as they employ (*a*) endless belts, *e.g.*, the Wetherill, (*b*) rolls, *e.g.*, the Wenström, (*c*) deflection, *e.g.*, the Edison, (*d*) circular tables, *e.g.*, the Thompson-Davis. Most of them require the crushed material to be in the dry state.

(*d*) Motion in air.—Appliances depending on motion in air are used where water is scarce or where the mineral is affected by water, but are not of wide application. The means employed are pneumatic jigs, fans or centrifugal concentrators (*see* No. 256).

In nearly all ore-dressing operations the chief difficulty arises from the large amount of useless material with which the valuable mineral

is associated; as machinery and processes improve, it is continually being found that some wastes rejected by earlier workers admit of profitable treatment.

ORE REDUCTION.

178. ANCIENT QUARTZ-CRUSHING MILL. Presented by The Hutti (Nizam's) Gold Mines, Ltd., 1911.

These boulders were found at Wondalli in the Dekkan, in territory belonging to the Nizam of Haiderabad, and are believed to have been the means used at a remote period for crushing and grinding quartz for the separation of the contained gold. Similar mills have been found in the Mysore goldfields. In these places there are evidences of extensive reef mining and as the quartz is hard, it is thought that both for its extraction from the mine and for its subsequent treatment it must have been subjected to fire and rapid cooling with water.

The resulting friable quartz must have been pounded with the stone muller and then ground fine by using a reciprocating movement. Probably the gold was then separated by washing in a wooden bowl. The boulder has been used in several places on both sides. M.3990.

179. MODEL OF TOOTHED ROLL CRUSHER. (Scale 1 : 8.)

This arrangement of rolls was patented by Mr. H. Mackworth in 1856, as a means for crushing bituminous shale prior to retorting. The two rolls are geared together and their surfaces are formed with blunt projections which alternate with each other but are not in contact. M.2631. 21,215 L.S.

180. MODEL OF STONE BREAKER. (Scale 1 : 2.) Presented by H. R. Marsden, Esq., 1869.

Mr. Eli Witney Blake, of Newhaven, Connecticut, U.S.A., introduced this stone breaker in 1853; since then it has come into most extensive use for crushing ore as well as for preparing road metal The crushing surfaces consist of two fluted jaws of chilled cast iron with removable faces. One of the jaws is fixed, while the other swings on a shaft above and is reciprocated 0·5 in. by a toggle-joint, formed of two plates, one butting against the lower part of the movable jaw and the other against the fixed framing of the machine; the toggle-joint is straightened by a connecting rod from an eccentric on the belt-driven fly-wheel shaft and is restored by a spring. The stones drop deeper into the hopper-like space at each reciprocation and are crushed as the jaws close. The distance between the jaws can be adjusted by means of the wedge, placed between the back plate of the toggle-joint and the framing, so as to pass the fragments when reduced to the required size. These machines run at a speed of 250 rev. per min., and, according to size, break from 4 to 13 tons of rock per hour to a size of 2 in. cube. M.1129.

181. MODEL OF STONE BREAKER. (Scale 1 : 8.) Presented by W. H. Baxter, Esq., 1883.

This modification of Blake's machine was patented by Mr. Baxter in 1878.

The movable jaw is pushed forward in the usual manner by a toggle-joint, but the latter is raised by a second toggle-joint worked by a crank and horizontal connecting rod. By this compound toggle a so-called "knapping" motion is obtained, which it is claimed reduces the amount of material delivered as dust. M.1619. 21,420 L.S.

182. BLAKE-MARSDEN STONE BREAKER. Lent by H. R. Marsden, Esq., 1888

In this modification of Blake's machine, patented in 1872 by Mr. H. R. Marsden, the jaw is moved forward by a disguised toggle-joint combined with a lever. The longer arm of a bell-crank lever is reciprocated vertically by a crank on the driving shaft, while the shorter end acts as a block between two toggle-plates, one of which abuts upon the frame and the other upon the back of the movable jaw. As in Blake's machine, the jaw is restored by a spring, and the space

between the jaws is adjusted by a wedge. Driven by a belt and a bevel gear from the fly-wheel shaft is a cylindrical screen for road metal; the holes are 0·875 and 2·25 in. diameter, so that three sizes are made. M.1923.

183. STONE BREAKER. Presented by Messrs. Robert Broadbent and Son, 1894.

In this modification of Blake's stone breaker, the reciprocation of the jaw is performed by an eccentric on the fly-wheel shaft driving the middle piece of a toggle-joint, while the return stroke of the jaw is given by a separate toggle motion, working in tension and connecting the lower extremity of the moving jaw with the framing; an adjustable spring takes up any play. The cushions or bearings in which the main toggle arms or plates work are of steel, and drop into recesses which are narrow at the ends to prevent a broken cushion from working outward. The screen is of two different diameters, superposed so as to reduce the length, and is driven as in the previous example; the perforations are 0·2 in., 0·8 in., and 1·5 in. diameter, so that four classes are obtained. M.2678.

184. ORE CRUSHER. Lent by the Gates Ironworks Co., 1891.

This is a crusher in which the reciprocating jaw of the ordinary machines is replaced by a gyratory crusher moving in a vertical conical shell; it was patented in 1881 by Mr. P. W. Gates, and subsequently improved. The upper end of the central spindle which carries the crushing head is socketed loosely in the top framing, so as to permit of the motion produced by the other end which is carried eccentrically in the boss of a horizontal bevel wheel from which the spindle gets its gyratory motion. The breaking head is of chilled cast iron, and tapers towards the top of the shaft, while the shell in which it works tapers downward and is fitted with chilled iron liners. Power is applied by a horizontal shaft which is connected to the heavy driving pulley by a readily renewable cast-iron pin, that in case of an accident will fail instead of any more expensive part. The material to be crushed is fed in through the openings at the top. The circular form of the crushers prevents the passage of unbroken flat pieces of rock, and the tapering of the crushing head spreads the material on to a larger surface as it is being reduced. The fineness of the crushed product is regulated by a set screw supporting the spindle. The broken material drops on to the shoot that covers the bevel gearing, and passes out through an opening in the shell (*see* sectional drawing, scale 1 : 8). A machine capable of breaking 2 to 4 tons of compact gold quartz per hour is stated to require 4 h.p. M.2399. 21,427 L.S.

185. MODEL OF CRUSHING AND GRINDING MILL. (Scale 1 : 4.) Received 1872.

In this machine, patented by Mr. G. H. Goodman in 1870-71, the ore is first broken by a jaw-crusher and then ground between horizontal discs. The jaw-crusher has a fixed jaw and also a movable one actuated directly by an eccentric on the driving shaft; the latter jaw has obliquely serrated chilled cast-iron faces, and by its motion exerts a combined grinding and crushing action.

The crushed material passes by a shoot into the hopper of a grinding pan below, which contains two horizontal cast-iron furrowed discs or stones in contact, the upper one being driven by gearing from the jaw-crusher. With gold and silver ores the pan can be used as an amalgamation mill, by constructing the lands of the stones with depressions to contain mercury. M.1762. 21,417 L.S.

186. HAND-POWER CRUSHING ROLLS.

This crusher was formerly used in small lead mines in Derbyshire. It has two plain cast-iron rollers 2·75 in. diameter by 8 in. long, connected by spur wheels and driven by two hand-wheels. One pair of bearings is adjustable by set screws so that the size of the crushed material may be regulated. The ore is supplied through a hopper, to which is hinged a shallow inclined tray supported by two arms resting on the teeth of the spur wheel, which thus cause the tray to vibrate and deliver the ore uniformly to the rolls. The rolls are cleaned by scrapers pressed against them by weighted levers. The crushed ore is delivered by a shoot into a sheet iron dish. M.2630. 21,416 L.S.

187. MODEL OF CORNISH CRUSHING ROLLS FOR COPPER ORES. (Scale 1 : 12.) Made by T. B. Jordan, Esq., 1842.

The rolls are driven through spur gearing in the ratio 4 : 1 by an overshot water-wheel 24 ft. diameter. The rolls are pressed together by a weighted lever which will lift should an unusually large piece be passed. The ore is fed in by hand, and the crushed material is delivered sideways down an inclined shoot into a revolving sorting screen, formed of longitudinal bars. The stuff that will not pass between the bars is led into a box, which, when full, is drawn up by a windlass and the contents again passed between the rolls. The water-wheel drives the windlass, the shaft being lifted out of gear by a lever and kept in by a spring. M.2629.

188. MODEL OF CORNISH POWER-CRUSHING ROLLS. (Scale 1 : 6.) Presented by John Taylor, Esq., F.R.S., 1851.

This is an improved form of roll crusher, employed at the Tywarnhaile mine, Cornwall, about 1850.

The rolls, which have thick cast-iron shells keyed on cylindrical centres, are 27 in. diameter, and geared together; the driver is 24 in. long and the follower only 18 in. The follower is pressed against the driver by weighted bell-crank levers, which limit the pressure to a safe amount. The crushed stuff passes from the rolls into a revolving trommel, 42 in. long, 24 in. diameter, covered with gauze of six holes to the sq. in. and having its axis inclined at 25 deg. The material which passes through the gauze is loaded by a shoot into trucks, while the coarse stuff is lifted by a raff-wheel, 15 ft. diameter, and delivered on to the charging platform to be passed a second time between the rolls.

A crusher of this size makes from 30 to 50 revs. per minute, and requires from 12 to 20 h.p.; it will crush from 40 to 60 tons of ore per day. M.2628.

189. MODEL OF CORNISH CRUSHING ROLLS. (Scale 1 : 24) Presented by W. A. Thomas, Esq., 1871.

These rolls, used at Devon Consols mine, closely resemble the preceding, but in addition the arrangement of the mill with its floors is shown.

M.2633. 21,202 L.S.

190. MODEL OF BALL AND PAN CRUSHERS. (Scale 1 : 8.) Contributed by Hyde Clarke, Esq., 1859.

These two models show the arrangement for grinding and amalgamating gold-bearing quartz, patented by Mr. Hiram Berdan in 1852.

The arrangement consists of a large open cast-iron pan about 6 ft. diameter, revolving on an inclined axis and containing two cast-iron balls of unequal size, the larger one weighing about 3,000 lb. In the model containing two pans, clutches on the driving shaft enable either to be thrown out of gear. Ore, which has been coarsely crushed, is put in the pans with a little mercury, and as the grinding proceeds the gold is collected by the mercury; the lighter material is washed by water that is kept flowing into the pan through spouts near the edge of the pan as they come to the lowest position. Inv. 1859—6. 21,201 L.S.

191. MODEL OF BALL MILL. (Scale 1 : 5.) Made by MM. Papault & Rouelle, 1910.

The fact that balls can be used for pulverising materials by impact had long been known (*see* No. 190), but it was not till about 1885 that the efficient form of mill represented by this model was brought out by Herr H. Gruson of Magdeburg; the mill is now known as the "Krupp," after the well-known firm who took over the Grusonwerk.

It consists of a drum, the interior of which is lined with chilled cast iron or hard steel plates, those round the circumference being arranged in a helical form so as to form a series of steps. The material to be crushed is introduced by a shoot around the axis. Inside, a number of steel balls of different diameters are taken round by the mill, which is rotated on a horizontal axis by gearing. The balls fall over one another and over the steps, pulverising the material partly between one another and partly between themselves and the plates.

The pulverised material falls through holes in the plates on to a surrounding coarse screen, which intercepts the large particles and prevents undue wear on the fine screen outside it; this is made up of quickly removable segments. What is too large to pass through the screens falls back into the interior through slits left between one plate and the next where the step is. Outside the screen is a fixed sheet iron casing, terminating in a shoot which delivers the finished product to a conveyor, &c.

The mill works dry and is suitable for a wide range of substances, but it can also be used wet; it is used mostly where fine reduction is necessary.

The mill is made in different sizes; that shown is 6 ft. diameter by 3·5 ft. wide; the weight of the balls charged is 2,640 lb.; their diameter varies between 2·5 and 4 in.; the speed is 26 rev. per min. and the mill is stated to require 15 h.p. to drive it. The capacity varies widely with the material acted on and the degree of fineness required. Observations made on hard quartz ore at Mt. Morgan showed that 1·75 tons were crushed to 0·025 in. mesh per h.p. in 24 hours; the wear of the balls was 0·72 lb. and that of the plates 0·68 lb. per ton of ore crushed. M.3797. S.M.236 L.S.

192. MODEL OF GRINDING MILL AND SIFTING MACHINE, (Scale 1 : 12.) Received 1865.

This mill was used in amalgamation works in Saxony; it resembles in its arrangements an old-fashioned flour mill. The sifted ore from the drum sieve (No. 216) is ground between granite millstones. The top millstone is fixed on a vertical shaft and is driven at 130 rev. per min. by crown gear from a water-wheel (shaft only shown). The fineness of the grinding is regulated by lifting, by a screw, the beam on which rests the footstep bearing of the vertical shaft. A shoot leads the ground ore to a rotating cylindrical sieve, the angle of inclination of which can be adjusted; this sieve discharges through a door in the hutch into a wagon alongside; the ore is further treated in an amalgamation plant. M.2782.

193. MODEL OF ITALIAN AMALGAMATING MILL. (Scale 1 : 8.) Made in the Museum, 1898.

This represents a pair of mills, 18 in. diameter, used in the north of Italy for gold extraction. Several of these pairs are usually arranged in series on the side of a hill, so that the same water drives them successively. Each pair of mills is fixed on a platform, and each lower stone is contained in a timber vat, the space between the sides of which and the stone is rammed tightly with sand and moss so as to form a strainer. The upper stone or runner is driven by two iron pegs, projecting downward from a crosshead, which is secured to the top of a vertical shaft passing through a wooden bush in the lower stone down to a timber post below. This post is the vertical shaft of an impact water wheel, 4 ft. diameter, resembling the modern Pelton, or "hurdy-gurdy," wheel. The wheel has twenty-four wooden vanes, slightly cup-shaped (an actual one is shown), and the driving water is brought to it by an inclined shoot or launder, the water reaching the wheel with a velocity of about 16 ft. per sec. The upper end of the launder opens into a head race where a wooden regulating sluice is provided. The lower floor of the mill is flooded with water while the wheels are in action, and the water, by sluices, is passed to the launders of the mills below.

Each mill deals with 73 lb. of ore per day of 24 hours; the ore, which has already been treated by stamps, is fed into the mill at intervals; after running for 12 hours about 7 oz. of mercury is added to collect the gold. The mill is flushed with water every eight hours, but the amalgam which collects in the packing within the tub is only withdrawn occasionally, through side orifices.
M.3026. 21,205 L.S.

194. MODEL OF EDGE-RUNNERS FOR CRUSHING "TORTA" (working). (Scale of details 1 : 8.) Received 1878.

This represents a special construction of edge-runners known in South America as an "arrastra," and used in the Mexican amalgamation process for extracting silver; it is arranged to give the grinding and mixing action that, since the invention of the process in 1557, has usually been obtained by the long-continued tramping of mules within an inclosure about 50 ft. diameter.

Continuous attention was necessary to ensure uniform treatment of the mud in which the animals worked, but, by the simple mechanical arrangement shown, greater uniformity is secured with less labour.

A circular bed is prepared and paved with stone, and round this is constructed a low wall or tub of timber, while in the centre is fixed a massive stone that has secured to it a horizontal wheel of forty-nine teeth. A pin on this centre carries a short arm that has a pin on it to which a horizontal bar is attached. This bar has two wheels or edge-runners loose on it, and at its extremity is provided with attachments by which mules, walking outside the enclosure, can pull the bar round. The pin of the bar has secured to it below a pinion of seven teeth gearing with the fixed wheel, and by this epicyclic gear the centre of revolution of the bar travels round the fixed wheel, so causing the runners to cover in successive turns the whole surface of the floor. By the introduction of an extra tooth or hunting-cog into the fixed wheel, the places missed by this model would be covered. The narrowness of the runners and the flexible attachment of their bar avoid any necessity for great accuracy in the surface of the floor.

M.1754. 21,423 L.S.

195. MODEL OF HUNTINGTON MILL. (Scale 1 : 6.) Lent by Messrs. Fraser & Chalmers, Ltd., 1907.

This centrifugal roller and ring mill was brought out in 1883 by Mr. F. A. Huntington for wet pulverising and amalgamating gold quartz, especially if of a brittle or argillaceous nature ; for this it is found superior to stamps, while its first cost and cost of operation are considerably less.

The ore from a stone-breaker is fed automatically through a hopper at the side of the pan in the centre of which is a vertical shaft driven from below by reduction bevel-gearing, usually in the ratio 2 : 1. This carries a horizontal frame in which are three or more pairs of pockets which support yokes from which grinding rollers are suspended about 1 in. clear of the bottom of the pan. The yoke allows the roller, which is free to revolve on its spindle, to swing radially outward against a renewable steel ring lining the pan ; the rollers, also, have renewable tires. The horizontal frame supports three or more fixed scrapers to throw the ore outwards ; when pulverised, the ore escapes through screens round the pan above the grinding level, thence by an annular launder to copper amalgamating tables, &c. About 75 per cent. of the gold is caught by mercury lying at the bottom of the pan and the rest by the tables.

The mill shown is 5 ft. diameter, crushes about 20 tons per 24 hours when running at 70 rev. per min., and requires 6 h.p. to drive it. M.3474.

196. MODEL OF CENTRIFUGAL PULVERISER. (Scale 1 : 8). Received 1905.

This model represents a grinding mill of the form patented by Mr. C. Lucop in 1875, and improved by Mr. J. U. Askham. Such mills are used for reducing cement, clinker, lime, phosphates, slag, &c.

The machine consists of a steel ring clamped between the two halves of a cast-iron casing, within which revolves a double arm fixed to a central shaft, and carrying at its ends steel rollers whose axles are free to move radially in slots, so that when the shaft is rotated they move outward and grind the material against the ring. The previously broken material is fed into a hopper at the top of the casing, and is carried on to the roller path by revolving blades. The ground material is forced through screens placed over the ends of the casings by propellers fixed to the shaft at each side of the roller arms ; it then passes by suitable channels through the bed of the machine whence it is removed by conveyors. The shaft is supported in a bearing at each end and carries a flywheel and pulleys. The mill has a grinding ring 24 in. diameter, by 4 in wide, and rollers 8 in. diameter ; it runs at 260 to 300 rev. per min., and reduces about 30 cwt. of average material per hour, for which it requires about 5 h.p. It is fixed to a wooden frame mounted on a concrete foundation. M.3405.

197. DISINTEGRATOR. Lent by J. Harrison Carter, Esq., 1890.

In this machine the four beater arms are of iron with hardened steel faces, the sides have renewable serrated chilled cast iron faces, and the screens are formed of bars of triangular steel to prevent choking.

The material to be pulverised is fed in at the periphery of the chamber and is at once struck and thrown against the lower screens through which the small fragments at once pass, the larger portions being thrown round against the upper bars and further reduced until they are small enough to escape through the lower screens, the grade of which determines the amount of reduction performed. Fibrous as well as granular materials can be pulverised in this machine which has, however, no grinding action, the beaters in every position being well clear of the stationary bars. The beaters make 4,000 revolutions per minute, giving a circumferential velocity of 262 ft. per second. M.2327.

198. " DEVIL " DISINTEGRATOR. Lent by the Hardy Patent Pick Co., 1894.

In this machine the material to be pulverised is subjected to a combined grinding and percussive action. Two renewable grinding rings are employed, one being secured to the casing and therefore stationary, while the other is attached to a disc which is rapidly revolved. Each ring is furnished with chilled cast iron teeth, arranged on their adjacent faces in concentric circles, with spaces between them. The teeth and spaces decrease in size towards the outside of the rings, and those on the fixed ring pass between the circles, of teeth on the revolving one. The clearance between the two rings can be adjusted while the machine is running, by a handwheel and screw which act upon the end of the revolving shaft. The materials to be granulated, or shredded, are introduced through a hopper into the centre of the machine. Wings on the revolving disc throw the material, by centrifugal action, between the teeth of the grinding rings, and the whole series must be passed before it escapes at the periphery, and so to the discharge orifice at the bottom of the casing. The teeth are largest where the rough material first enters and get finer and closer as the fragments become smaller. The shaft runs at 900 revs. per minute, giving a circumferential velocity of 74 ft. per second. M.2381.

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199. PARTS OF PRIMITIVE STAMP MILL. Presented by F. W. Oldfield, Esq., 1905.

These stone shoes, with the corresponding twin die, are from the province of El Oro, in Ecuador, where they formed part of the primitive stamp mill for gold-bearing quartz shown in the attached prints. The construction is traceable to Spanish influence, and is believed to have been introduced about the 17th century; the mill shown was actually in use till 1880.

The battery consisted of two stamps, the shoes and dies being simply boulders of andesite picked from the river bed. The shoes are dressed roughly square and tapered to fit into the socket in the end of a stem of squared timber working between wooden guides. In the stem was a slot for an arm which acted as a tappet and was raised by four lifters cottered to an octagonal wooden shaft driven by an overshot water wheel. The lifters were arranged so as to raise the shoes alternately. The dies were roughly dressed to start the wear and were wedged in place with smaller stones. The mortar was formed by a wooden housing, the screen being a piece of board pierced with nine holes for plugs to regulate the height of discharge and hence the fineness of the crushing. The pulp from the battery flowed through a channel 12 ft. long by 15 in. wide, filled with blanket in 3 ft. strips; the coarser tailings were caught in a large hole and returned to the battery. The free gold and concentrates washed from the blankets were amalgamated in a " batea " or wooden dish.

The life of the shoes and dies was about 25 days. Each battery crushed in 24 hours, 400 to 600 lb., chiefly of the soft oxidised ore found on the surface. M.3409.

200. MODEL OF STAMPS FORMERLY USED IN SAXONY. (Scale 1 : 20.)

The cam-barrel is an oaken shaft connected to the axle of an overshot water-wheel. Of the stamp heads shown, two sets of three are for wet stamping—the general practice in preparing ores for concentration—whilst one set of three are for dry stamping, the stamps being used instead of rolls for rich silver or lead ores. The ore is supplied to each wet set from a hopper by a shoot which receives a jolting from a projection on one of the lifters; the water is supplied from a

launder. The dry set is fed with ore by hand. The floor on which the wet heads work is of hard vein stuff rammed between a framing of longitudinal bars; the dry heads work on a cast-iron anvil supported on wooden piles. The wrought iron heads weigh 300 lb. and are fixed to square lifters of alder. Each stamp is lifted three times for every revolution of the wheel, the amount of lift being 14 in. for the wet, and 9 in. for the dry heads. M.2623. 21,415 L.S.

201. MODEL OF STAMPS USED IN CORNWALL. (Scale 1 : 24.) Made by T. B. Jordan, Esq., 1842.

This shows the original arrangement of the stamps erected by Mr. J. Sims for crushing tin ore at Carn Brea mine, Redruth.

There were 72 stamp heads arranged in line, with the steam engine in the middle; the engine drove the cam barrels by a pair of clutches. The stamps were arranged in sets of three, divided from each other by upright posts, to which were attached thick oaken planks forming a closed box or "cofer," 20 in. deep. The bed was formed of hard quartz stamped in between walls of masonry to a depth of 18 in. The ore, previously broken into lumps of about 2 cub. in., was brought in wagons along an incline raised about 10 ft. above the ground, and delivered into bunkers whence it is fed into the cofers. Water run in with the ore carried off the fine stamped particles through perforated copper plates in front of the boxes, the holes being from 0·025 to 0·033 in. diameter. The stamp heads were of white cast iron, socketed in the wooden stem and secured by two iron bands. Each head was lifted five times for every revolution of the engine. The cam-barrels were cast iron flanged cylinders bolted together.

M.2621. 21,425 L.S.

202. MODEL OF STAMPS USED IN CORNWALL. (Scale 1 : 6.)

This represents one set of four stamps at Par Consols tin mine, Bodmin. The lifters are of fir, and guided back and front by vees from the cross-bars of the framing. The shorter sides of the "cofer," as well as the front, are provided with discharging grates; the front grate, which is unusually large, measures 23·5 in. by 7 in. high. The weight of the stamp head was 644 lb., the lift 10 in., and the number of strokes 50 per minute. The amount crushed per head per 24 hours was about 17 cwt. M.2622. 21,206 L.S.

203. MODEL OF IRONSTONE DRESSING MACHINE. (Scale 1 : 12.)

This is a combination of stamps with a rising current separator, and was patented in 1855-6 by Mr. H. Mackworth as a means for freeing nodules of ironstone from attached clay. There are seven stamps arranged in two rows, all working on a cast-iron floor. The stamped ore is received in a conical tub, in which revolves a vertical stirrer, and is carried through by a current of water maintained by a force pump. The flow carries the shale to the top and discharges it, while the cleaned ironstone collecting at the bottom is raked out through a door in the front. M.2625.

204. MODEL OF STAMPS USED IN AUSTRALIA. (Scale 1 : 16.)

The improvement seen in these stamps, first introduced in 1851 in California, consists in an arrangement by which their heads are rotated so as to give a certain amount of grinding action and also to prevent irregular wear.

The heads are cylindrical and cast on to wrought-iron lifters; the tappets are small cylinders keyed to the lifters, and the cams act on their lower faces, so causing the heads to rotate through about 120 deg. at each lift. The ore is placed in a large hopper behind the stamps and fed into the boxes by two shoots, which receive a jolting motion. The stamped ore is washed away through a grating in front of the mortar-box and passes over a shallow trough containing mercury; it then passes over a series of inclined tables broken into low steps and covered with coarse serge blankets.

The stamps used in the Clunes gold mine, Australia, in 1864, had Bessemer steel heads weighing 784 lb., struck 76 blows per minute, and crushed 54 cwt. of ore per 24 hours. (*See* No. 169). M.2624.

205. MODEL OF STAMP BATTERY. (Scale 1 : 16.) Lent by R. E. Commans, Esq., 1891.

This represents a modern form of gravitation stamp battery, having two sets of five stamps. It consists of a timber framing strengthened by iron tie bolts, although wrought-iron frames are sometimes adopted. The stamps are lifted, frequently in the order 1, 4, 2, 5, 3, by double-ended cams, keyed to a horizontal shaft which rotates in bearings bolted to the framing. Each shaft carries five cams, and is driven independently by belting from a counter shaft running along the back of the battery. The ore is fed from hoppers into the mortar boxes, which are furnished with steel dies to receive the blows of the stamps. The ore when pulverised is washed out through the front screens by a stream of water, about 270 cub. ft. being required for each ton stamped. Free gold contained in the ore is caught in front of the mortar boxes on copper plates, coated with quicksilver, which retains the gold by amalgamation.

The weight of a single stamp varies from 500 to 900 lb., according to the hardness of the ore to be crushed; it makes 80 to 90 drops of 6 in. to 10 in. per minute, and crushes from 1·5 to 4 tons of ore per 24 hours; smaller machines are made for prospecting purposes. M.2397.

206. MODEL OF STAMP BATTERY. (Scale 1 : 8.) Lent by Bertram Gray, Esq., 1898.

This represents a modern five-head battery, and shows, in addition to the other details, the massive timber foundation on which the mortar box, which receives the blows of the stamp, is bedded. The timbers of this foundation are bolted and dowelled together, but are independent of the main framing, as they rest on a block of concrete at a considerable depth below the ground level. The other arrangements are very similar to those shown in No. 205.

The cam-shaft is driven at a speed of about 95 rev. per minute, by a belt passing over a wooden pulley built on a metal centre. Each stamp weighs from 450 to 1,300 lb. and has a drop of 7 to 8 in.; the guides for the stamp stems are formed in adjustable hard-wood blocks. To throw any stamp out of action a row of "jacks" or levers pivoted on a shaft behind the stamps is provided; any jack when swung forward will catch under its tappet collar when in the highest position, thus preventing that stamp from falling. Each tappet collar is secured to its stem by a key, which is tightened up by two or three transverse cotters. M.3031.

207. MODEL OF STAMP BATTERY. (Scale 1 : 6.) Lent by the Sandycroft Foundry Co., Ltd., 1899. Plate III., No. 1.

This represents a modern form of gravitation stamp battery of 10 heads, used for gold milling. The stamps are, as is usual, in sets of five, quite independent. The description refers to one such set.

The framing is of the "high-bank" type, i.e., the ore bin is incorporated with the stamp framing; it is of pitch pine held together by iron tie rods. The ore is supplied from a hopper to each set of stamps through a sliding door actuated by a rack and hand wheel and slides down a shoot on to an automatic feeder—an improved form of that originally introduced by Joshua Hendy. It consists of an inclined plate which is caused to revolve by an adjustable friction feed motion obtained from a bumper rod struck by a tappet on the middle stamp stem when a deficiency of ore below it causes it to fall low enough. The fixed vanes resting on the plate sweep off the ore into the mortar box.

The stamps are guided in removable hard wood bearings arranged on the front of the framing. They have iron stems and steel shoes striking on steel dies embedded in a concrete base below; tappets on the stems are acted on by double-ended steel cams fixed by Blanton's keys (*see* No. 209) to a horizontal shaft on bearings in the framing. The stamps are lifted in the order 1, 3, 5, 2, 4, which is that most favoured on the Rand. The cam shaft is driven by belting from a counter-shaft below the floor. By releasing a jockey pulley toggle tightening arrangement, any set can be independently disconnected. A row of "jacks" is provided (*see* No. 206). The mortar box is made of cast iron of trough section with a screen of wire cloth in front through which, as it is pulverised, the ore is washed by a stream of water from a supply pipe on the frame. The pulverised material flows down troughs lined with copper plates coated with mercury which retains the gold by amalgamation. These are often succeeded by blanket tables (not shown).

The weight of each stamp head varies from 800 lb. to 1,300 lb., and the height of the lift from 6 in. to 9 in. The amount crushed varies from 3·5 to 5 tons per stamp per diem, according to the nature of the ore and the mesh of the screen used. M.3074. 31,091 L.S.

208. MODEL OF MORTAR BOX FOR STAMP MILL. (Scale 1 : 6.) Lent by Messrs. Fraser & Chalmers, Ltd., 1907.

The mortar box is constructed so that the front is removable, as patented in 1901 by Mr. D. B. Morison, for convenience in obtaining ready access to the interior, particularly for renewing the dies, shoes and lining ; the last named are usual in modern practice. The lining and fittings shown are of the kind patented in 1904 by Mr. D. A. Bremner. The linings extend from the hopper mouth to three sides of the interior ; they are built up in sections for convenience in handling, and have wearing plates riveted to the front. For checking the ejection of " pulp " a canvas screen is hung on the inside of the hopper. The front of the mortar box is closed by a pressed steel plate which is hung from a crane jib so that it can swing out of the way. The front plate and the screen are held in place by nuts with handles whose weight is adjusted to act under vibration so as to tighten the nut. M.3472.

209. MODELS OF CAM FASTENINGS. (Scales 1 : 4 and 1 : 8.) Lent by Messrs. Fraser & Chalmers, Ltd., 1907.

This method of keying a wheel, &c., to a shaft so that it is capable of being easily removed, was patented in 1893-7 by Mr. E. A. Blanton. It has been widely adopted for fixing cams to shafts of stamp mills as shown ; it has also been applied to the transmission of power.

Two forms are shown. In the first a tapered liner embracing part of the shaft is pinned to it to prevent relative movement between them. A corresponding recess in the boss of the cam, usually cut in a relieving lathe, fits over the liner, and a slight rotative motion causes a wedging action. To transmit motion in the reverse direction the liner and cam must be placed on the shaft in the opposite sense. In the second case a number of eccentric projections or relieved surfaces are formed on the shaft to fit corresponding recesses in the bosses of the cams. In this case the number of recesses is a multiple of the number of the cams so that they can be altered to lift in the sequence that is found most suitable, while they will always assume the correct angular position to one another. M.3473.

210. MODEL OF NELSON'S ORE FEEDER. (Scale 1 : 18.) Presented by Fraser & Chalmers Engineering Works of The General Electric Co., Ltd., 1919.

This machine represents an improved form of the " Challenge " automatic ore feeder, the purpose of which is to keep up an even flow, and to control the quantity of ore from ore bins, &c., to crushing stamps and concentrating mills.

The apparatus is shown applied to a stamp battery ; it consists of an inclined table, rotation to which is given by a grip bar acting directly on the table. This bar is so arranged that when the bumper lever is depressed by the collar or tappet of the middle stamp stem, it grips the grip ring of the table, and at the same time it moves it forward—rotating the table with it, and the ore is swept off by a vane into the mortar box. As soon as the lever is released by the collar or tappet, the grip bar is returned to its original position by means of a helical spring. The amount of feed or motion given to the table is regulated by a hand wheel which adjusts the stroke of the bumper lever. The supply of ore from the hopper on to the table between the vanes is controlled by the adjusting bar and bracket. Inv. 1919—217.

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211. MODEL OF BARREL PULVERIZER. (Scale 1 : 8.) Made by Messrs. F. Bartle & Sons. Received 1909.

This shows an apparatus for wet-grinding ore to a very fine state of division. It is an adaptation of the idea embodied in the " rumbler," or machine for cleaning or polishing articles by revolution with hard material in a barrel.

The form shown, however, was patented in 1880 by Mr. F. W. Michell and Mr. H. T. Tregoning. It consists of a cylinder of cast-iron, on trunnion bearings, rotated by reducing spur gearing by power at about eight revs. per minute. Rough pieces of steel or iron are introduced through the outer trunnion bearing, and the ore to be ground is led from the hopper with a stream of water by means of a pipe through the other bearing into the interior of the barrel. When the ore is ground sufficiently fine to remain in suspension in the water, it passes out with it through the trunnion to a launder.

The apparatus is now superseded by the improved form known as a tube-mill. (*See* No. 212). M.3597.

212. MODEL OF RAND TUBE MILL. (Scale 1 : 8.) Made from particulars supplied by Messrs. Fraser & Chalmers, Ltd., 1914. Plate III., No. 2.

The tube mill is a development of the principle embodied in the Cornish barrel pulverizer (*see* No. 211). It was at Kalgoorlie, Western Australia, that fine grinding by pans and tube mills for the treatment of telluride gold ores was first introduced in 1899 by Dr. L. H. Diehl. It was not till 1904 that the first tube mill was started on the Rand by Mr. J. R. Williams of the Glen Deep Mine, but in the year following, the mill met with general acceptance.

As the name indicates, the mill is a plain tube with a refractory lining between which and loose pebbles or balls the sand pulp from a stamp battery is reduced to slime pulp as the tube is rotated. The action which takes place is due partly to attrition and partly to percussion.

Mills vary in size from 3·5 to 5·5 ft. in diameter and from 13 ft. to 26 ft. in length. On the Rand the usual dimensions, as shown by the model, are 5·5 ft. diameter and 22 ft. long. The shell is of steel 0·75 in. thick with welded or butt riveted joints ; the ends are of cast steel with radial ribs. Two manholes about 19 in. by 13 in. on opposite sides of the shell are provided for access to the interior ; the doors are made tight with rubber or insertion. The shell is rotated by gearing in the ratio 4.5 : 1 on tires and anti-friction rollers or else, as is more usual, on hollow trunnions as shown. One of the trunnions—the driving end—serves for the feed of battery sand pulp and pebbles and the other for the discharge of slime pulp. Many forms of feeder have been introduced ; that shown, devised by Mr. L. Pryce, consists of a spiral passage between two discs so that there is an opening at the periphery leading by an easy descent to the centre where there is a short screw conveyor to pass the pebbles through the trunnion to the interior. The de-watered sand pulp is introduced through an open funnel communicating by a pipe with the outer disc. At the discharge end, there is a grate or screen, with holes tapering from 0·5 in. to 0·75 in., that keeps back the pebbles ; the diameter of the discharge being larger than that of the feed, gives a gradient for the discharge of the pulp.

The lining has received much attention and several kinds are shown, viz. :— (*a*) The commonest, composed of silex or chert blocks dressed to a thickness of 6 in. or 7 in. and laid to break joint ; (*b*) The El Oro lining which consists of hard cast-iron segments bolted to the shell ; they have projecting ribs parallel to the axis of the mill and tapered to make the space between them wider at the top than at the root so that the blocks, &c., will wedge in but can easily be removed and replaced ; (*c*) The honeycomb, patented in 1906 by Mr. H. P. Barry, is formed of light cast-iron frames of 4 to 6 cells bolted to the shell ; quartzite, &c., is cemented in each cell ; (*d*) In the Osborn lining, steel bars of tapered section set edgewise parallel to the axis are wedged in by bars set flatways. The space between the bars is wider at the top than at the root, the idea being the same as in the El Oro lining.

In a mill of the size shown, the weight of the pebble load the level of which is 3 in. above the axis (assuming 105 lb. to the cub. ft.) is about 15 tons, while the weight of the pulp (assuming the interstitial space at 40 per cent.) is about 4·5 tons. The output per 24 hours from coarse battery screened ore would be about 100 tons ground to a fineness of 90 mesh, but the output varies considerably with the hardness of the gangue. As the lining wears, the volume increases, and so in a greater proportion does the output. The life of silex linings is from 90 to 100 days, that of chert about 80 days. The speed of the mill varies from 28 to 34 revs. per minute and the power required is about 100 brake h.p.

(*See* "Text-Book of Rand Metallurgical Practice," Vol. i.).

Inv. 1914—298. S.M. 853.

SIZING.

213. STANDARD LABORATORY SCREENS. Presented by Messrs. N. Greening & Sons, Ltd., 1916.

This is a set of the screens recommended as standard by the Institution of Mining and Metallurgy in 1904, and now widely adopted.

The screens are intended for laboratory use in making grading tests and for the correlation of screens used in commercial or other work.

The aims kept in view were to limit the tendency to excessive refinements in grading tests by reducing the number of sizes to a minimum and to ensure that the screening area remains as nearly constant as possible at 25 per cent., i.e., equality of diameter of wire and size of aperture.

The result is that there are seventeen sizes designated by the number of apertures per lineal inch in each, i.e., 5, 8, 10, 12, 16, 20, then rising by 10 to 100, 120, 150, and 200.

In reporting grading tests, it is desirable to state whether wet or dry screening has been employed. Inv. 1916-2.

214. MODEL OF SIZING MACHINE USED AT FREIBERG. (Scale 1 : 8.)

This is an arrangement of flat rectangular sieves for classifying the ore passed through a crusher. The sieves are of uniform breadth, but the length and also the mesh of the wire gauze decrease from above downwards; the sieves are suspended from one another by links at an angle of 11 degrees. Each sieve receiving a jolting motion from a vertical cam-shaft, the return movement being given by gravity, the ore is delivered from a large hopper on to the topmost sieves and the jolting causes all particles larger than the mesh to fall over the fronts into their appropriate bins. The number of classes produced is five or one more than the number of sieves. M.2586. 21,213 L.S.

215. MODEL OF SAXON SIZING TROMMEL. (Scale 1 : 6.)

This is a plain horizontal drum for sizing the sands from a stamp battery. The drum is of light iron-work 4 ft. diameter by 5·5 ft. long, divided into three lengths in the ratio 2 : 2 : 1 and covered with wire gauze; the first has 150 holes to the square inch, the second 75, and the third 30. The surface is cleaned by jets of water. The drum makes 7 rev. per min., and as its axis is not inclined, a screw conveyor is introduced to move the ore along.

Trommels of this character are now very generally used for sizing ores; the wire cloth, for all but the smallest sizes, is replaced by perforated plates, and each trommel separates but one size. If the drum is cylindrical, the axis is inclined; but if conical, the axis is horizontal; by these arrangements conveyors are dispensed with. M.2587. 21,218 L.S.

216. MODEL OF ROTARY SCREEN USED IN SAXON AMALGAMATION WORKS. (Scale 1 : 8.) Received 1865.

The ores intended for amalgamation after having been roasted with salt and iron pyrites in a reverberatory furnace (*see* Metallurgy Catalogue) are sifted through an eight-sided drum sieve contained within the hutch, and having a slight inclination; the upper bearing of the axle is cylindrical, while the lower has a cam-wheel attached to it which rests on a step-shaped bearing giving one a slight lateral jerking motion to the sieve as it revolves. The ore is fed through an inclined trough, which receives a jerking motion from a cam-wheel and lever acting against a wooden spring beam. The gauze covering the upper part of the sieve is of double thickness, and separates a sufficiently fine-grained material for grinding (*see* No. 192); the bulk of the stuff passing through the single thickness is again sifted through a finer sieve; the coarser lumps are returned to the calciner to be roasted with a fresh addition of salt. M.2714. 21,541 L.S.

217. MODEL OF VIBROMOTOR SCREEN (working). (Scale 1 : 5.) Made from drawings supplied by the Hardy Patent Pick Co., 1906.

The vibromotor, patented in 1892-3 by Mr. W. W. Beaumont, and since considerably modified, is a means of giving gyratory motion to an object such as a screen by the action upon it of an unbalanced force when the whole system is freely suspended.

A weight attached to an arm keyed on a spindle is rotated from overhead by a flexible shaft or by an electric motor. The spindle, in common with every other part, would revolve round the centre of gravity of the whole were its path not modified owing to the fact that the bearing in which it rotates is attached to the screen. The resultant gyratory motion which is thus impressed on the whole system may be modified in character and amplitude by varying the position of the weight on the arm and the load on the screen. It is claimed that the whole of the work transmitted through the spindle, neglecting friction, is used within the system, so that no vibration is transmitted to the supporting framework. Screens on this plan can, therefore, be driven at a much higher speed than can screens driven by the crank, cam, or eccentric method.

The screen shown is for grading coal into three sizes. It is constructed entirely of metal, and suspended by wire ropes held in clips. The bearing on the screen is of large diameter, and the revolving weight is carried by a ball bearing.

M.3467. 30,884 L.S.

218. MODEL OF MARCUS CONVEYOR (working). (Scale 1 : 12.) Made in the Museum from drawings supplied by Messrs. Head Wrightson & Co., Ltd., 1914.

This trough conveyor, which is adaptable also as a screen, embodies improvements patented in 1900 and 1904 by Herr H. Marcus. The model shows a coal conveyor mounted on a staging of rolled joists and arranged for screening into three sizes.

The mechanism employed to give motion to the screen is the draglink coupling with the centres so arranged that constant angular velocity of the driving crank produces a varying angular velocity in the "propulsion" crank, a connecting rod from which gives motion to the conveyor. The velocity of the trough increases from zero rapidly till three-quarters of the stroke is reached, then slows down during the last quarter. The motion on the return stroke is the inverse of that on the forward stroke (*see* diagram). The consequence is that the material as it is carried forward eventually acquires sufficient impetus to overcome frictional contact between it and the trough during the return stroke. It is claimed that the relative position of every piece of coal keeps on changing so that the trough is suitable for picking as well as screening. The motion is not found to be trying to the eyes as might be expected. The trough can be placed horizontally or even with a slight upward inclination so permitting a saving in the height of buildings. The driving mechanism is on a self-contained bed plate at one end. The speed, too, is low compared with other oscillating conveyors, *i.e.*, one for conveying 300 tons of coal per hour has a stroke of 12 in. and requires only 65 revs. per min. using 7 h.p. The restricted number of working parts and the slow speed render the cost of maintenance slight.

The trough is supported on rollers mounted on independent axles whose bearings are held to the trough and to the track by the intermediary of helical springs which prevent the trough jumping off the track and also from running out of line.

Inv. 1914—467. S.M. 585.

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219. MODEL OF POINTED BOX CLASSIFIER. (Scale 1 : 12.) Presented by J. W. Arundell, Esq., 1863.

This is a modification of an arrangement introduced by Rittinger in 1844, in which classification is effected by a series of settling boxes, hanging from the floor of a shallow trough that is conveying the stuff from the stamps. The bottoms of the boxes are formed as hoppers to facilitate emptying. These separators are generally used for classifying ore which is too fine to be successfully sized by sieves.

In the modification shown, which was patented in 1862 by Mr. Arundell, the slime is first mixed with water and passed through a drum sieve of perforated copper, into a launder 13 in. broad, at the upper end of which it mixes with a stream of clean water. The pointed boxes, four in number, are of the full width of the launder, but of increasing length; the heaviest particles are deposited in the first box, while the lighter ones pass on to the second box, and so on. The fine stuff which passes to the fourth box is run to waste.

M.2588. 21,197, 22,093 L.S.

220. MODEL OF CONICAL SLIME SEPARATOR. (Scale 1 : 12.) Presented by J. W. Arundell, Esq., 1863.

This is a rising current apparatus, patented by Mr. Arundell in 1862. Like No. 219 it is used rather for classification than for concentration. A machine differing slightly from this was introduced in 1859 by Mr. Borlase into the lead mines of the north of England.

The machine has an inverted conical plug within a conical hopper, the two leaving between them a passage of uniform area, so that the rising current of water has a constant velocity. Above the plug is another conical hopper, which acts as a distributor for the slimes introduced above it. The current is so regulated that the bulk of the light earthy material is carried over the top by the current, while the heavier particles are discharged at the bottom of the conical case.

M.2589. 21,197, 22,093 L.S.

221. SPITZKASTEN. (Scale 1 : 12.) Made from particulars supplied by Messrs. Fraser & Chalmers, Ltd., 1916. Plate III., No. 3.

This is an apparatus for classifying mineral too small for sieves by subjecting it to an upward current of water. The apparatus was developed after exhaustive experiments by P. von Rittinger from the pointed boxes in series which he had introduced in 1844.

The apparatus consists of a series of inverted pyramidal boxes to the apex of each of which water under a pressure of a few inches is introduced. A stream of pulp is fed in at the top over a spreading launder into the smallest box. The heaviest particles sink while the remainder are carried over the edge of the box by a smaller launder into a second box of about twice the size of the first, and so on, the size of the particle that can settle being smaller the larger the box. The mineral that settles is drawn off from the bottom of the box through rubber hose. The water is introduced also through hose adjusted for height by block and tackle.

Rittinger recommended four boxes, the width of each being twice that of the previous one; others have recommended 1·5 times as the proportion, but the relative dimensions are best arrived at after experiment with the particular ore which is to be treated.

In the model the dimensions are as follow: First box 30 in. long, 11 in. wide, 20 in. deep; second box 60 in. long, 19 in. wide, 40 in. deep; third box 90 in. long, 38 in. wide, 62 in. deep; fourth box 130 in. long, 75 in. wide and 90 in. deep. The angle of the sides of the boxes is 75 degrees and of the ends 55 degrees.

(*See* Rittinger-Lehrbuch der Aufbereitungskunde 1867, 164 *et. seq.*)

Inv. 1916—341. S.M. 1268.

MINERAL CONCENTRATION.

222. MODEL OF CORNISH KEEVE OR DOLLY TUB. (Scale 1 : 4.) Presented by Capt. W. Teague, Jun., 1882.

This appliance, consisting merely of a tub in which the finely divided ore is stirred and then allowed to settle, is specially used for the final concentration of lead and tin ore.

The stirring (*tossing*) is done by paddles on a vertical axle rotated by a bevel gear and clutch from a power shaft. The settling in classified order (*packing*) is assisted by taps on the outside of the tub from a hammer continuously tripped by a cam on the shaft; the water is drawn off and the deposit scraped off layer by layer.

M.2582. 21,207 L.S.

223. HAND SIEVES.

These Cornish sieves, formerly used for dressing tin ore, show the simplest form of jigging appliance. The charge of ore is placed in the sieve, and is given a series of short jerks in a tub of water. The heavier ore settles to the bottom of the sieve. One of the sieves is 18 in. diameter by 5 in. deep, and has a bottom of iron wire gauze with holes 0·125 in. square; the other is 20 in. diameter by 5·5 in. deep, and has a bottom of copper plate perforated with holes 0·05 in. diameter and about 0·4 in. pitch. M.2601-2.

224. MODEL OF AUSTRALIAN PUDDLER. (Scale 1 : 16.)

This machine is used in Victoria to remove clay from gravel containing gold; the idea appears to have been borrowed from the similar machine used in brickmaking. It consists of an annular trench lined with iron or hard wood, and having in it triangular drags attached to radial arms that are fixed to a central post. This post is directly rotated by a horse walking in a circular path or by other power, and the clay is so puddled by the drags that it is carried off by the water flowing through the trench, leaving behind a clean gravel which is then put through a cradle (*see* No. 225) to collect the gold.

M.2579. 21,200 L.S.

225. MODEL OF CRADLE AND UTENSILS FOR GOLD WASHING. (Scale 1 : 4.) Received 1856.

These appliances constitute one of the simplest outfits employed in alluvial gold digging, being readily obtainable anywhere.

The cradle is a rough wooden box on rockers; in the head is an easily fitting sieve of perforated sheet iron into which is shovelled gold-bearing gravel or "pay-dirt," while water is poured over it by the tin dipper and the cradle is rocked by a handle. The gold, sand, and fine particles carried by the water through the sieve are guided by an inclined frame below the latter to the head of the box, and flow down the sloping bottom. A blanket stretched over the frame retains very fine particles, while coarse gold is caught by transverse ledges or "riffles" on the bottom. The pebbles left in the sieve are picked over by hand, in case a nugget be present, before being thrown aside. When there is sufficient accumulation on the bottom, the sand is separated from the gold by agitation in the tin dish in a tub of water. This method is slow and wasteful.

M.2580. 21,428 L.S.

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226. MODEL OF TINSTONE DREDGER. (Scale 1 : 50.) Lent by Messrs. Werf Conrad, Ltd., 1919.

The dredger represented, which fulfils the double purpose of excavating gravel and separating the tinstone contained in it, was built in 1908 by Messrs. Werf Conrad for the Renong Dredging Co. for use in the Renong and Pak Chan Rivers, Siam.

The dredging method for the recovery of tinstone from river beds, alluvial flats and benches, is of comparatively modern date, and is a development of the similar mechanical appliances previously used for the recovery of gold. There is a considerable variation in the construction of such dredgers to suit the depth and character of the deposit and other local conditions.

This dredger is of the usual ladder and bucket type and will dredge in advance of its own flotation to a depth of 39 ft. The excavated material is discharged from the buckets into a trommel 5·25 ft. diameter by 29·75 ft. long, which has six screens, interchangeable and replaceable when worn. The sizes of the perforations in the screens are decided upon by experiment, and may vary from 0·3 to 0·5 in. diameter; in some cases, as in the present one, all the perforations are of the same size. The inclination of the trommel can be adjusted to suit the flow and character of the alluvial wash. The finer material passes through the screens while the larger portions of the gravel are rejected, washed down the centre launder, and deposited astern.

The material passing through the trommel is passed over a series of transverse tables—six short launders on each side—at right angles to the trommel and to the main longitudinal sluice launders. These short launders or tables, which are adjustable for gradient, are 4 ft. wide by 18 in. deep. The length of the first is 14 ft., and each succeeding table is 2 ft. shorter. The main purpose of these tables is to convey the alluvial sand and water over the main sluices, which are the dressing sluices. The latter are 4 ft. wide by 18 in. deep, and the longest is 80 ft. Large settling area is here necessary, due to the lower specific gravity of tinstone as compared with that of gold. On each side of the sluices, at intervals of 6 ft., vertical iron guides are riveted for receiving wooden riffles. As the tin concentrates are deposited so the wooden riffles are built up. Only three sluices are at work at the same time, whilst the fourth is being cleaned up. To allow of this, each of the tables above mentioned has a movable lengthening piece 4 ft. long.

The bucket and screen are driven by a two-cylinder two-stage expansion condensing engine of 115 h.p. The water for sluicing purposes is supplied by a centrifugal pump delivering 300,000 gallons per hour, driven by a similar engine, but of 150 h.p.

The dimensions of the dredger are: Length, 118 ft.; breadth, 40 ft.; depth, 7·7 ft.; the buckets are 12 cub. ft. capacity. To counterbalance the varying weight in the sluices, ballast tanks are so arranged in the hull as to give an even keel.

The quantity of tin concentrate obtained, and the working costs, vary widely with the nature of the ore deposit and with local conditions. The results with this dredger over a period of 40 months' working are stated to have been the treatment of 122·6 cub. yd. per hour, and the recovery per cub. yd. of gravel of 0·9 lb. of tin concentrate of the value of 12·6*d*., while the cost of treatment was 6·6*d*. Inv. 1919—391.

227. MODEL OF RIFFLE FOR SLUICES. (Scale 1 : 4.) Presented by H. Bauerman, Esq., F.G.S., 1881.

This riffle was patented in 1881 by Mr. W. H. Howland, to take the place of the ordinary riffle bars in the flume or sluice carrying auriferous material or sulphides from a stamp mill. It is made of cast iron in sections, each consisting of an anticlinal ridge with grooves on both slopes parallel to the direction of the current. At the ridge and also at the foot of the tail slope are troughs to hold the mercury. The sections are placed breaking joint in the flume, to produce eddies which assist the separation of the particles of gold and their collection by the mercury. M.1590.

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228. MODEL OF HAND JIGGING MACHINE. (Scale 1 : 8.)

This is a simple form of jig, once much used in Cornwall for concentrating copper ores. The sieve is a rectangular box or "hutch" 57 in. long, 24 in. broad, and 10 in. deep, supported from the short arm of a compound lever by two vertical iron bars. A square wooden pipe supplies clean water over one side of the hutch, and the muddy waste water is carried off on the opposite side. The hutch measures 90 in. long, 43 in. broad, and 45 in. deep. An iron scraper is used to remove the contents of the sieve, which is usually classified into three parts; the uppermost is thrown away, the middle requires further treatment, while the bottom is clean ore fit for sale. The fine stuff passing through the sieve collects in the hutch, and is subsequently treated on the round buddle or other slime-washing machine. M.2603, 21,210 L.S.

229. MODEL OF CORNISH JIGGING MACHINE. (Scale 1 : 12.) Received 1842.

A water-wheel, 14 ft. diameter with an external spur ring, drives two cranks that give a jigging motion to two levers from which the sieves are suspended; four slots in the suspending links enable the sieves to be raised independently by a hand lever for emptying. In other respects it resembles No. 228.
M.2605. 21,212 L.S.

230. MODEL OF HUTCHING MACHINE. (Scale 1 : 12.) Presented by T. Sopwith, Esq., F.R.S., 1851.

This machine was made by Mr. J. Hetherington, and used at the Allenheads mines, Northumberland. The sieve is formed of parallel rods, and is suspended by vertical links from counterbalanced levers that are kicked by fourteen pins on the faces of two revolving wheels. The shaft can move longitudinally so as to draw the pins out of gear with the levers. A small winch is fitted for use in lowering the sieve into the hutch after emptying.

M.2604. 21,198 L.S.

231. MODEL OF JIGGING MACHINE USED IN SAXONY. (Scale 1 : 8.)

In this machine the sieve is fixed and the water moved, a modification which appears to have been first introduced into Cornwall by Mr. Petherick in 1831, and is now in very general use, especially for coal washing.

The machine represented was constructed for dressing argentiferous lead ore. It consists of a wooden hutch divided into two square compartments, in one of which is a zinc plate perforated with holes about 0·125 in. diameter, and in the other a plunger 27 in. square, attached by a rod to a wooden lever, which is raised by a revolving eccentric and falls by the action of the weight of a loaded box. The crushed ore is placed on the sieve and subjected to the alternating currents of water forced through it by the plunger, whose stroke is 3 in. An opening in the partition dividing the compartments is provided with a sliding door for regulating the current; this is closed when filling or cleaning the sieve. The launder is for running off the dirty water.

These machines were generally arranged with a sieve on each side of the plunger, so that one might be cleared and refilled while the charge on the other was in process of concentration. M.2606. 21,208 L.S.

232. MODEL OF JIGGING MACHINE. (Scale 1 : 12.) Presented by J. W. Arundell, Esq., 1863.

This jigger is similar to No. 231, but the compartments are the legs of a cast-iron **U**-tube of rectangular section; the sieve is fixed in one leg and the plunger is worked by a cam in the other. The "hutchwork," or fine stuff which passes through the sieve, is discharged through a hole at the bottom into a settling pit; the waste water is replaced by a pipe, and there is the usual sliding partition for separating the two compartments. M.2592. 21,197, 22,093 L.S.

233. MODEL OF JIGGING MACHINE. (Scale 1 : 3.) Presented by Ministerialrat P. von Rittinger, 1862.

This is a continuous jigging machine, with the suspended sieve reciprocated horizontally only; vertical motion is given to the water by a lift pump.

A crank pin moves the bucket, which contains four leather-faced iron clacks, and the bottom of its box has four similar foot-valves; the water passes through the sieve and returns to the hutch through the foot-valves. The ore is fed in along an inclined trough, vibrated by a cam which also causes the sieve to oscillate, both being returned by adjustable spring beams. The ore, in addition to being sorted by the water, is worked forward by the shaking motion of the frame. On arriving at the end of the principal sieve the deposit is cut horizontally into three layers by the edges of three sorting sieves; the lowest takes the best ore, which passes into the first box No. 1, the second quality into box No. 2, and the lightest is discharged by the top sieve into box No. 3; the fine stuff passing through the sieves is removed through two mud-holes at the bottom of the hutch.

An actual machine, with a pump of 3 in. stroke making 75 rev. per min., treated 1·5 tons of ore per hour, and required 0·75 h.p.

M.2608. 21,421 L.S.

234. MODEL OF REMFRY'S JIGGING MACHINE. (Scale 1 : 6.)

This is a continuous jigging machine, and represents a type much in use for treating ore from 0·25 in. down to 0·04 in. The mesh of the sieve is slightly greater than the size of the ore, but is reduced by a bed of clean ore of larger grain first placed on the sieve.

The machine consists of a rectangular water box with a semi-circular bottom, divided into three similar double hutches. In one compartment of each hutch is a fixed sieve, and in the other a piston reciprocated by an eccentric on an overhead belt-driven shaft. The stroke of the piston can be varied from 3 in. to zero, and the number of strokes is from 80 to 300 per min., according to the fineness of the ore. The ore is delivered from a classifier to one end of the line of sieves, and as each sieve is at a slight inclination and a little below the previous one, the ore travels forward. The heaviest particles sink through the bed into the first hutch and the lighter ones into the second and third, while the lightest pass over the end into a tank as tailings. There is a hand-wheel to each hutch for emptying it into a settling tank below.

Specimens of galena produced by each hutch are shown,

M.2578. 21,426 L.S.

235. MODEL OF HYDRAULIC CLASSIFIER (SPITZLUTTE). (Scale 1 : 4.) Made to order from information supplied by G. W. Leech, Esq., 1915. Plate III., No. 4.

This is used to remove the coarser particles of the mineral from the crushed ore before it is passed on to the intermediate stages of concentration.

The arrangement consists of an outer and inner set of cones. The inner cone is raised or lowered by a screw-and-wheel attachment held in position by a diagonal support. By this means the annular space between the cones is adjusted in accordance with the requirements of the ore pulp and the ascending clean water. To the base of the outer cone is attached a small cone-shaped box with an inner tube and diaphragm connecting with the supply of clean water at a pressure of from 6 to 12 lb. The water pressure, the annular space between the cones, and the height of the delivery pipe are adjusted according to the character of the ore and grade of concentration. The crushed pulp is fed into the inner cone and, passing downwards, it meets the upward flow of clean water from the small cone into the larger outer cone. The heavier particles pass downwards, and the lighter portions of the pulp flow upwards between the cones and are discharged into the circular launder, and thence on to the finer stages of concentration. The capacity of this form of classifier is in proportion to the fineness and character of the crushed ore, usually from one to two machines for ten heads of stamps.

The dimensions are :—Inner cone : Width 2 ft. 8 in., depth 2 ft. 7 in. ; outer cone : width 2 ft. 6 in., depth 2 ft. 4 in. ; angle of sides 70 degrees ; constructed of 0·125 in. mild steel ; length of inner tube and diaphragm 18 in. ; diameter of water pipe 1·75 in. ; discharge pipe 1·75 in. diameter.

Inv. 1915—434. S.M.770.

236. MODEL OF SCHELL'S ROTATING TABLE. (Scale 1 : 12.) Presented by D. Zenner, Esq., 1860.

This shows the original form of the rotating table invented by Herr Schell, of Clausthal, in 1854. It consists of a convex wooden table fixed to a vertical shaft rotated by a worm-gearing from a water-wheel (not shown). The slime is stirred with water by paddles in a box, which has a coarse grating at the inlet and a finer one at its outlet to the launder. The slime is distributed on to the table by a central ring launder, one-fourth of its length delivering slimes and the remaining three-fourths jets of clean water, while a special launder furnishes additional water jets.

The classified ore reaches the circumference at different points, the lightest first. To receive it there is an annular launder divided into sections of different lengths, each with its own discharge pipe. The greatest section of this launder receives tailings, and the shortest is reserved for the concentrate, for the removal

of which reciprocating and fixed brushes are necessary to assist the water. This machine showed a great saving in time and labour when compared with the old shaking table.

(*See* Min. Journ. xxx., 124.) M. 2597. 21,203 L.S.

237. MODEL OF SAXON ROTATING TABLE. (Scale 1 : 12.)

This model shows a modification of Schell's table (*see* No. 236), erected in 1855 at the Himmelsfürst mines in Saxony; it is driven by shafting and worm-gearing from an overshot water-wheel 6 ft. diameter.

The slimes, mixed with water in a box, are delivered at one point only, while the ring launder, extending two-thirds round the shaft, brings the wash-water which flows over a spreading cone before reaching the table. The launder at the circumference has no partitions, but its bottom slopes in opposite directions; the tailings are delivered into a single pit, and the classified concentrate into a double one. M.2598. 21,199 L.S.

238. MODEL OF CONCAVE ROTATING FRAME. (Scale 1 : 6.) Presented by Ministerialrat P. von Rittinger, 1862.

This machine was first introduced in 1860 by Von Rittinger, at Chemnitz, n Saxony, for dressing poor slimes. It is a shallow concave cone, 16 ft. diameter, attached to a vertical shaft rotated by worm-gearing. The surface is divided into thirty-two segments by strips of wood 0·75 in. high. The slimes are mixed in the slime box by a rotary paddle and then passed to the eleven fixed head-boards, occupying an arc of 320 degrees above the frame; of these boards, the spreaders, Nos. I., III., V., and VII., deliver slime, while the alternate ones, II., IV., VI., and VIII., deliver water, as do the three hinder ones, which are smaller, and have their outer edges cut into a series of steps.

Supposing the ore under treatment to contain galena with pyrites and matrix, the action would be as follows: As the frame revolves, a particular segment receives a layer of slime from No. I. head-board; water from No. II. board then carries off the lighter particles, and leaves the heavy ones on the frame; the segment receives more slime from No. III., which is washed by water from No. IV., and so on till the segment has passed No. VIII. It then retains a concentrate of galena and pyrites, which is cleaned off by water from the three hinder boards, which deliver streams of increasing force. The clean lead ore remains, and is washed off by a jet of water from a pipe. Each of the segments of the frame has, at its lower end, a square vertical wrought-iron shoot for discharge.

Experiment proved that the best results were obtained when the speed was six revolutions and 0·66 cu. ft. of slime or 0·93 lb. of solid ore were being fed on to the table per minute. M.2600. 21,418 L.S.

239. MODELS OF CONVEX ROTATING TABLES. (Scale 1 : 12.) Presented by J. W. Arundell, Esq., 1863.

These two models show a modification patented by Mr. Arundell in 1862.

The rotating table is of cast iron, driven by bevel gear. Slimes from the pointed box classifier (No. 219) are introduced at one point only; the washing water is supplied by a perforated annular pipe, connected to the main supply at several points by cocks so that the force of the jets may be varied as desired, and perforated tangential pipes are used for flushing off the concentrate. The tail launder is divided into three parts, covering respectively arcs of 30 degrees, 90 degrees, and 240 degrees, each with its own discharge pipe and catch-pit.

M.2590. 21,197, 22,083 L.S.

240. MODELS OF CONCAVE ROTATING TABLES. (Scale 1 : 12.) Presented by J. W Arundell, Esq., 1863.

This form of table was first introduced in Rhenish Prussia in 1861, and is sometimes known as a funnel frame. Except that the flow of slime and water is from the outer to the inner circumference, the machines are similar to the adjacent convex tables (*see* No. 239). M.2591. 21,197, 22,083 L.S.

241. MODEL OF SAXON SHAKING TABLE. (Scale 1 : 16.) Presented by John Taylor, Esq., F.R.S., 1842.

The machine has a rectangular table about 14 ft. by 6 ft., with raised edges on the sides, and is supported in an inclined position by four chains. The two chains at the lower end hang vertically from a horizontal axle, by which the slope of the table for the various grades of ore can be adjusted. The shaking motion is communicated by a bell-crank lever, the arm of which is adjustable and is acted on by cams on a revolving horizontal shaft (not shown).

The crushed ore is mixed in a slime box and distributed by a head-board over the table where, under the combined influence of the shaking motion and a stream of clean water, the lightest particles are removed. The work is continued till a layer of about 6 in. thick has accumulated, when the table is stopped and the classified deposit shovelled off in sections.

The stroke varies from 7·5 to 9·5 in., and the number is from 30 to 40 per min. for coarse sand, and 35 to 45 for finer slimes; the volume of water required is from 8 to 9 times that of the ore in the first case, and from 1·5 to 2·5 times in the second case. M.2610. 21,211 L.S.

242. MODEL OF SHAKING TABLE. (Scale 1 : 12.) Received 1842.

This table, introduced by Mr. Robert Stagg in 1828, was used at the Northumberland lead mines of the London Lead Co.

There are two paddle-wheels for more thoroughly mixing the slimes, and the front pair of chains is adjustable by long screws; otherwise the apparatus is similar to No. 241.

(*See* Sopwith—Account of the Museum of Economic Geology, 1843, 91.)

M.2611. 21,216 L.S.

243. MODEL OF CONTINUOUS SHAKING TABLE. (Scale 1 : 6.) Presented by Ministerialrat P. von Rittinger, 1862.

This shows the arrangement adopted in the first experimental machine made by Von Rittinger in 1858. The table is suspended by four links, and receives a jolting motion, at right angles to the flow of the washing water, from a cam, the return strokes being given by a wooden spring beam. The slime is introduced from a mixing box over a distributing board, and a stream of clear water over another. The heaviest particles of ore, being but little affected by the downward flow of the water, move to the left under the jolting action, while the lightest ones are carried straight down; particles of intermediate densities follow paths varying in inclination with the edge of the table so that the richest ore passes over at the left-hand end and the seconds and waste at the lower edge. The table is 6 ft. long by 3 ft. broad and has a stroke of 2 in. In practice, the difficulty of discharging the ore sideways at the low velocity required led to a modification in the construction, by which the discharge was confined to the lower edge and the output increased. M.2612.

244. MODEL OF SHAKING TABLE. (Scale 1 : 4.) Lent by The Wilfley Mining Machinery Co. Ltd., 1907.

The action of this continuous ore separator, like its prototype the Rittinger table of 1858 (*see* No. 243), is dependent upon rapid oscillation in a direction at right angles to the flow of the pulp. The appliance was introduced in 1895 by Mr. A. R. Wilfley, and has been modified in construction since; the model represents a recent form.

The table is trapezoidal in plan, 15·8 ft. long, 6 ft. wide at the head, tapering to 5 ft. wide at the tail end; to avoid warping, it is constructed of red-wood strips laid diagonally, ribbed with wood-filled pressed steel stringers below. Linoleum, having proved to be the most satisfactory working surface, is the covering used; lengthwise on this are nailed wooden riffles 1·37 in. apart, centre to centre. These vary in length from about 4 ft. at the feed side to the full length of the table at the discharge side; also they taper in depth to a feather edge at the tail end. The table rests on rockers supported by transverse beams on a longitudinal timber balk; the beams can be tilted to the necessary angle by cams actuated by bevel gearing and a hand wheel.

The table receives adjustable motion lengthwise from the toggle joint, straightened by an eccentric driven by belting; the speed of the table consequently is greatest when near the end of the stroke, so avoiding lost motion of the ore particles. The slime or pulp is fed without splash from a trough attached to the table along the higher side; on the same side, but fixed to the framing, is a trough for the wash water.

The particles acted on by the water, shaking, and gravity follow a curved path modified by the riffles, which assist in detaining the heavier particles while allowing the lighter ones to be washed over. At the lower tail corner the middlings discharge into an inclined trough whence they are raised for further treatment by a scoop wheel actuated by gearing from the driving pulley, or they may go to another table. The rest of the discharge consists of tailings.

The speed of the table would be 240 double strokes of 0·75 in. per min.; the power required is 1 h.p. The capacity at this speed, depending on the nature of the ore, is stated to be from 15 to 30 tons per 24 hours, with a consumption of 200 gallons of water per hour. M.3484. 31,770 L.S.

245. MODEL OF SWEEPING TABLE. (Scale 1 : 12.) Made by Herr Carl Schumann.

This modification was devised by Mr. Okladine in 1854, for gold-washing in Siberia. The wash-dirt is delivered, suspended in water, on to a short table inclined at 10 degrees, upon which the heavier materials are deposited, while the lighter ones pass off with the water. This deposit is subjected to the action of three sets of brushes, which make 25 upward sweeps per min.; during the down strokes the brushes are lifted above the table by hinged curved plates, and so have no action. At every sweep the deposited materials are re-exposed to the action of the down-flowing stream, so that more of the light matter is washed off and the concentrate therefore improved. The machine is stopped at intervals and the concentrate cleared off the table for further treatment.

The brushes depend from a frame, reciprocated by a crank and carried by rollers that rest on the main framing; in the path of the rollers are four curved plates which act as inclines only on the down stroke.

Beyond the sweeping table is a stepped amalgamation table, on which the material is stirred by rakes actuated similarly to the brushes. The tailings from this pass into a shallow pan fitted with a revolving agitator, by which the lighter materials are kept in suspension so that they pass off with the water. M.2585. 21,209 L.S.

246. MODEL OF CORNISH ROUND BUDDLE. (Scale 1 : 6.) Presented by John Taylor, Esq., F.R.S., 1851.

The round buddle, first used in Cardiganshire, was subsequently employed in Cornwall for dressing poor copper ores; the example shown is from Tywarnhaile mines.

It consists of a convex wooden floor about 15 ft. diameter, in a shallow pit. At the centre is a cone, which serves both as a spreader and as a footstep for a vertical shaft with two arms, carrying brushes (*missing*). The vertical shaft is driven by an inclined shaft on which are projecting knives working in a cylindrical slime mixer followed by a drum screen with eight holes to the inch. The refuse from this screen is discharged by the vertical shoot on to the edge of the buddle whilst the slimes pass by a launder to a funnel at the centre, whence they flow over the spreading cone on to the inclined floor. The heaviest particles settle first, while the lightest escape at the circumference through holes in a sluice board provided with plugs at different heights. The brushes prevent the formation of gutters on the surface; they are counterbalanced by cords over pulleys to adjust them to the continually varying slope. When the deposit has accumulated to a depth of 6 to 12 in. it is dug out in two or three concentric rings of graduated richness.

At the present day the spreading cone is made of cast iron, 4 to 6 ft. in diameter, six or eight arms are used, the slope of the floor is 6 or 7 degrees, and the number of the revolutions of the brushes is about 6 per min.; 1·5 to 2 tons of stuff are treated per hour. M.2596

247. MODEL OF CONCAVE BUDDLE. (Scale 1 : 12.) Received 1865.

This form was introduced by Mr. E. Borlase in 1858, and differs from the last mainly in being concave. The slime pan is of cast iron, with six launders to deliver the slimes to the circumference, whence they flow towards the centre where the tailings escape, whilst the richest portion of the ore deposits itself near the edge. A central shaft rotated by worm-gearing carries round six brushes and, by gearing, rotates a stirrer in the slime box. M.2599.

248. MODEL OF BUDDLE AND JIGGING MACHINE. (Scale 1 : 24.) Presented by W. A. Thomas, Esq., 1871.

This represents an arrangement used at the Devon Consols mines. The buddle is similar to No. 246, and the jigger is of the original type with the sieve moved up and down in a hutch. It is counterbalanced, and can be worked by hand, but both machines are connected to a power-driven shaft.

M.2584. 21,204 L.S.

249. BUDDLE SCRAPER. Presented by H. Rosales, Esq., 1874.

This scraper for a buddle is of wood, and has along the edge a strip of india-rubber backed with iron, in this respect resembling a squeegee. It was in use for two months at the Walhalla Gold Mines, North Gippsland, Victoria. M.2581.

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250. MODEL OF SLIME TRUNKING MACHINE. (Scale 1 : 10.) Presented by John Hunt, Esq., 1851.

The hand buddle or trunk is a long rectangular box with a sloping bottom and an end provided with a vertical row of discharge holes. The ore is placed on a raised part at the back of the trunk and worked with a spade in an entering stream of water, which carries away the slime, and deposits the heavy particles along the floor at distances corresponding with their "equivalents." As the deposit increases, the overflow orifice is raised; the deposit is finally removed in sections.

The model represents a machine used in Brittany for dressing waste from some old workings. It has a distributing sieve, with holes 0·06 in. diameter, particles remaining on which are jigged. The trunk is 9·5 ft. long, 4·5 ft. wide, 2 ft. deep, and has its floor inclined at 8 degrees.

(*See* Mech. Mag., lvii., 481.) M.2593. 21,214 L.S.

251. MODEL OF SLIME TRUNKING MACHINE. (Scale 1 : 12.) Presented by M. Attwood, Esq., 1854.

This arrangement was introduced in 1849 by Mr. Attwood, at the lead mines of Alston Moor, Cumberland, and consists of three trunking machines and a dolly tub.

The slime is thrown into a box into which clean water is also delivered, and is there subjected to the action of revolving blades which break it up. After mixing, the material is screened through a curved perforated plate, and the refuse swept off into a launder. The fine stuff, after undergoing a further mixing by a second paddle-wheel, is delivered on to an inclined table where it meets a stream of clean water, and falls into one of the rectangular tanks, which have their floors inclined at about 2 degrees to the horizontal. The richest ore from the trunks is prepared for market in the adjoining dolly tub (*see* No. 222); the stirring paddle can be lifted vertically in guides out of the tub, which can then be run out on rails; the hammer is on a horizontal rod driven by cogs. The whole of the apparatus is driven by a small overshot water-wheel.

M.2594. 21,419 L.S.

252. MODEL OF SLIME-WASHING TABLE. (Scale 1 : 12.)

This is an old machine, formerly used in Saxony, but now displaced by the rotary table. The table is 14·5 ft. long by 3·75 ft. broad, and is placed at a slight inclination that is adjustable by wedges. The surface is of hard wood, planed, and then slightly roughened by sulphuric acid. The slime, mixed with water in a box and screened, was delivered at the upper end of the table on a head-box provided with studs for distributing the stream uniformly. The flow continued until a layer 0·125 in. thick was formed over about three-quarters of the surface, when the supply was stopped and a gentle current of water turned

on, which carried the lighter impurities over the end of the table into the waste launder. The lowest third of the material on the table was swept by a movable launder into one division of the ore box below; the middle third was swept into the other division, first passing through the sieve; while the top third, by reversing the launder, was swept with the aid of water into the good ore box below the table. The cycle of operations took about twenty minutes.

M.2595. 21,424 L.S.

253. MODELS OF CORNISH SLIME FRAMES. (Scale 1 : 6.) Made by J. T. Letcher, Esq., 1892.

This shows a double set of self-acting slime frames, as used in tin-ore dressing, for treating the tailings from the buddles, and so recovering any heavy particles not already separated.

The tailings or slimes are brought in a long trough running along the top of the machine, and another trough in front brings a supply of water to be used in flushing the frames. The frames are furnished with lozenge-shaped spreaders, which distribute the slimes uniformly over the slope. Down these inclined surfaces the slimes gently flow, the heavy tin-ore particles settling on them, while the lighter refuse flows into a trough below. The upper part of each slope is crossed by a water-trough so pivoted that, when filled to a certain height, the time being regulated by the water supply at the side, the trough overbalances and the sudden discharge of its contents sweeps the deposited ore down the slope. This overbalancing of the trough also opens the cover of a trough at the base of the slope, and at the same time shields the ordinary waste trough from receiving the tin ore. In one section of the model the slopes are divided into two steps, but the greater portion of the ore is deposited on the upper ones. The balanced water-troughs are replaced in position by hand levers, as shown in the other section of the model, but, in the first-named section, a small box at right angles to the trough fills with water after the balanced trough has tilted and brings it back again into its initial position, so rendering the machine completely automatic. The scoop-wheel between the two frames is to lift the slimes from the first up to the level necessary for treatment by the second, and the small revolving screen here introduced is to remove any exceptionally large material. After leaving the frames the slimes pass over several settling tanks before being finally rejected. The deposited material in the tanks is afterwards dug out and re-treated. M.2484. 21,737 L.S.

254. MODEL OF BRUNTON'S BELT. (Scale 1 : 24.) Presented by W. A. Thomas, Esq., 1871.

This arrangement, used at the Devon Consols mines, was patented by Mr. William Brunton in 1844. The fixed table of the Cornish slime frame (*see* No. 253) is replaced by an endless canvas belt, at a slight adjustable inclination, reinforced by cross-laths of wood on the underside. At a third of its length from the top is a head-board, which delivers the slime on to its surface. Near the head a stream of water is delivered and runs down the belt, carrying the lighter particles with it, while the heavier particles stick to the belt, which travel continuously in a direction opposite to that of the stream, until they are washed off while passing through a tank of water below. The tailings run off the belt into a box on wheels, by which they are removed, or may be carried off through a trough.

The modern Frue vanner greatly resembles this machine, but in it the canvas is replaced by an india-rubber belt with raised edges which, in addition to travelling up-hill, is given a side-shake. M.2583. 21,422 L.S.

255. FROTH FLOTATION PLANT. (Scale 1 : 8.) Made from particulars supplied by Messrs. Minerals Separation Ltd., 1919. Plate III., No. 5.

This sectional model illustrates a method of ore concentration, rapidly increasing in importance at the present day, whereby metallic sulphides in an ore pulp are separated by flotation. The method is based on the property that certain sulphides have of attracting selectively oils and gases; hence the mineral particle becomes surrounded by an envelope which lowers the specific gravity of the whole sufficiently to render it capable of floating on water.

The first to recognise that oily substances have a greater affinity for sulphides and metals than for earthy substances, and to base a process thereon, was William Haynes in 1860. In 1886 H. Bradford devised a process depending on the property that gases have of adhering to certain minerals rather than to others.

In 1885 Dr. J. Everson instituted a long series of experiments and showed (*a*) that acid added in small quantity greatly increases the selective action of the oil, and (*b*) that rapid agitation of the pulp facilitates the separation of the oiled mineral from the gangue. Subsequent inventors, F. E. Elmore, A. E. Cattermole, A. J. de Bavay, C. V. Potter, G. D. Delprat, H. L. Sulman, Hugh Pickard, T. J. Hoover and others, carried the processes further.

The plant shown embodies the patents of the three last-named; the distinguishing features of importance are that the quantity of oil used is small, that air in minute bubbles is present in the pulp, and that agitation is used to assist in throwing up the sulphide ore as a froth.

The plant is made in units, comprising usually eight cells or mixing-boxes; five of these, one being in half-section, are shown in the model. In each cell is a Howard agitator rotated at about 200 rev. per min. by overhead bevel-gearing and shafting. The pulp flows into the first box by the launder shown, and while doing so the reagents are added. Either vegetable oil, such as eucalyptus, or mineral distillate oils can be used, the choice being governed largely by available supplies. The chemical introduced to promote action of the oil, depending on the composition of the latter, is either suphuric acid, caustic soda, sodium sulphite or sodium carbonate. The kind of oil and of chemicals to be used are best decided upon by experiment. On reaching the mixing-box the agitator brings the reagents into intimate contact with the pulp and with each other, at the same time disseminating air through the mass. At the side of each cell, and in communication with it by an opening 12 in. from the bottom, is a pyramidal chamber or spitz-box. In the bottom below the agitator there is another opening 5 in. diameter communicating by a pipe and controlled by a valve with the spitz-box next adjacent, and so on in series. In this way continuous circulation is kept up and no deposition of gangue can take place. The froth concentrate as it is thrown up overflows the edge of the spitz-box into the launder, assisted thereto by a slowly revolving paddle, and after settling is ready for metallurgical treatment. The residues or tailings gravitate into large settlers or ponds and about 65 to 75 per cent. of the water, with a corresponding economy in consumption of reagents, is returned to the plant. It is stated that the economy of the process is such that it has been found possible to treat profitably ores which hitherto have been considered valueless, *e.g.* ores containing as little as 0·8 per cent. of copper and smaller quantities of silver.

The cells are 31·5 in. by 53 in. inside, constructed of 8 in. by 2·5 in. tongued and grooved pine with a lining of jarrah for the working part of the cell. The framework is mainly of timber. An eight-cell plant has a capacity for treating about 500 tons per day.

(*See* Sulman—A Contribution to the Study of Flotation, Bull. Inst. M. & M., 182, 1919; also Broadbridge—Froth Flotation: Its Commercial Application and its Influence on Modern Concentration and Smelting Practice, Bull. Inst. M. & M., 184, 1920.) Inv. 1919—263. S.M.1259, 1265.

256. MODEL OF PNEUMATIC SEPARATOR. (Scale 1 : 5.) Made by M.M. Papault and Rouelle, 1909. Plate III., No. 6.

Instead of the ordinary screen for the separation of dust from pulverised material, a blast of air has been successfully used, and the same means has been adopted for the concentration of ores when the wet method is impracticable. The blast may be continuous or pulsating; in the former case advantage may also be taken of centrifugal action as in the separator shown, which resembles in general principle that patented in 1888 by T. W. B. Mumford and R. Moodie.

The apparatus has a sheet-iron shell, the upper part cylindrical, the lower conical, with an outlet at the bottom. Concentric within this is a sheet-iron cone with an outlet through the side of the external shell. The material to be separated is fed into a hopper above, in the centre of which is a vertical spindle rotated by bevel-gear from the driving pulley. This spindle has, at its lowest end, a distributing disc, above which a fan is fixed by inclined struts. Two annular diaphragms or baffles of sheet iron are suspended round the disc and below the fan.

The entering material is thrown by centrifugal action against these baffles, while the fan establishes a current of air axially, drawing up the fine dust, while the large grains drop into the interior cone and pass through its outlet to be re-ground. The air, with the dust in suspension, passes into the outer chamber, where the speed of the current is so reduced that the dust falls by gravity to the outlet; the action somewhat resembles that of the "cyclone" dust separator.

The grade of product can be regulated by altering the speed of the fan, but slight variations may be made during working by an annular diaphragm which

alters the space through which the air has to pass on its return to the distributing disc. The apparatus is closely sealed so as to prevent the escape of dust. The speed of the fan is 250 revs. per min., and 0·5 h.p. is required for driving.
M.3639. S.M.234 L.S.

COAL WASHING.

257. MODEL OF COAL-DRESSING MACHINE. (Scale 1 : 8.)

In this apparatus, patented in 1856 by Mr. H. Mackworth, the coal to be cleaned is delivered by a shoot into a separating chamber containing water, and having a floor of perforated plates, through which the water is continually being jerked upward by a large single-acting circulating pump contained in the machine. The separator is divided by a nearly vertical perforated plate, and is surmounted by a perforated, travelling, endless apron provided with projecting blades. Owing to the motion of the water the heavy shale alone arrives at the bottom of the separator, where it collects in a chamber, while the coal is divided into two classes by the vertical screen, and carried to the delivery shoot by the apron, through which the water passes on its way back to the pump. The fine dust is drawn away from the entering coal by a fan, which projects it upon the wet cleaned coal, so that it does not pass through the water.
M.2607.

258. MODEL OF ELLIOTT COAL WASHER. (Scale 1 : 16.) Made in the Museum from particulars supplied by The Hardy Patent Pick Co., 1913.

A trunk or trough, down which the particles of a mineral to be concentrated are carried by a stream of water over distances depending upon its specific gravity, is the simplest form of classifier. The trough washer shown, patented in 1892 by Mr. G. W. Elliott and subsequently improved, is an apparatus of that type specially designed for separating coal from shale, but highly developed in that it is continuous and automatic in action. As the relative sizes of particles of coal and shale falling in water, i.e., their "equivalents," is about 3·5 : 1, the material, first freed from dust, must be screened within these limits and each size treated in a separate washer. The sizes recommended are 0·06 in. to 0·31 in.; 0·31 in. to 0·62 in.; 0·62 in. to 1·25 in.; 1·25 in. to 2 in. Coal above 2 in. is rarely washed.

The trough is placed at an inclination of 1 in 12; it is made of sheet steel and has a flat bottom with sloping sides. At each end of the trough are one or two sprocket wheels engaging with an endless single or double chain to which, at suitable intervals, scrapers of the same outline as the lowest part of the trough and resting on it are fixed. The chain returns over rollers bearing on brackets bridging the trough. The screened material is delivered through a divided shoot about midway along the trough to a primary washer having shelves, where it meets with water from a number of jets in a transverse pipe. The material is thus thoroughly saturated—an important point, especially with the smaller sizes—and the larger pieces of shale are at once separated. The material falls into the trough and the coal, being light, is carried over the scrapers, eventually reaching a draining screen at the lower end, while the heavier shale is pushed upwards. Near the top it meets a fresh influx of water from the main water box so as to free from it any remaining pieces of coal. The shale is delivered by a shoot to a dirt conveyor. The water leaving the trough drains into a tank, generally under the washer. A scraper conveyor moving slowly along the bottom carries the mud as it settles to the upper end. The clear water is used over and over again.

The chains are driven by a three-coned headstock with fast and loose pulleys. The pitch of the scrapers, their size and shape, whether flat, corrugated, or serrated in section, the speed of the chain and the volume of water all require to be suited to the size of coal being washed. The trough is 60 ft. long; for a single washer it is 18 in. wide at the bottom and 30 in. at the top; for a double washer the dimensions are 27 in. and 39 in. The output varies from 4 tons per hour for the smallest size to 12 tons per hour.

The general arrangement of an Elliott coal-washing plant is seen on a diagram adjacent. M.4239. S.M.347.

259. MODEL OF COAL SCREENING AND WASHING PLANT. (Scale 1 : 50.) Lent by The British Humboldt Engineering Co., Ltd., 1911.

This shows the plant erected at Rheinpreussen Colliery, Westphalia, by the Maschinenbau-Anstalt Humboldt, of Kalk, near Cologne.

The output is classified into lump coal, nuts of four sizes, fine coal, and dust ; the nuts and fine coal only are washed, the dust being added to the latter at the finish. The plant is in duplicate, to meet the event of stoppage or of reduction in output.

Screening Plant.

The loaded tubs from the pit bank run by gravity down an incline of 1 in 50 to the tipplers, where their contents are tipped into enclosed swinging screens. The tubs return by gravity to the shaft, creepers being arranged to bring them back to the pit-bank level. The screen is perforated with holes 85 mm. diameter, and underneath it is a solid plate provided with a shutter. When the latter is open the small coal drops into bunkers below ground level, and the lump coal passes to the picking belt. If for any reason the shutter has to be closed both kinds of coal pass together over the picking belt, but as the lumps are on top it is easy still to pick out the shale. The coal is loaded into railway wagons by shoots, raised or lowered by electrically operated winches.

The shale is picked out by hand and thrown into tubs, which are wheeled to a hoist, raised to the next platform, tippled into a shoot leading to a stone-breaker, and thence dropped directly into railway wagons.

Each unit is driven by shafting and belting from an enclosed motor.

Washing Plant.

The output of each unit of this plant is 100 tons per hour, of which 40 per cent. is nuts of sizes in millimetres 80–55, 55–32, 32–20, and 20–10, while 60 per cent. is fine coal, 10–5 mm., and dust below 5 mm.

The small coal from the bunkers is raised by bucket elevators to the top of the building and delivered to the fixed enclosed dust screen. The dust passes by a side shoot to a trough below the floor, while the coarse stuff passes by a shoot to the main flow jigging machine. When washed the stuff passes with the wash water to the nut-classifying screen, whereby the four sizes of nuts and fine coal mentioned are obtained. The nuts pass by spiral shoots (to eliminate breakage) into their respective nut coal hoppers. A loading conveyor below takes nuts, being sprayed with water meanwhile, from any one hopper at will, and passes it to a rising and falling shoot, delivering into railway wagons.

The fine coal passes by a shoot into a sump, whence it is raised by a bucket elevator and delivered by shoots to the fine coal jigging machine, where it is rewashed. Thence it is carried by a belt conveyor over a preliminary draining screen and dropped on to the slow-running draining conveyor, which resembles a series of boxes hinged to one another.

The dust previously extracted is delivered by a belt conveyor to a point about the middle of these draining conveyors, and distributed over them by a screw conveyor at right angles.

If there is a shortage of fine coal, provision is made to divert washed nuts to a mill situated over the sump, into which the ground nuts drop. Provision is also made for introducing fine coal from outside sources. A bucket elevator raises it from a bunker, where it has been dropped from railway wagons, and delivers it at the point where dust is added to the draining conveyor. This latter delivers its load to a screw conveyor at right angles, which can, if necessary, deliver into the neighbouring coal tower as well as its own. The even distribution is effected by a table with a rotating scraper arm. At the base of the tower are discharge gates so that this fine coal, which is intended for coking, can be filled into coke-oven wagons to go direct to the ovens.

The shale is taken from the bottom of the two jigging machines by a screw conveyor and raised by a bucket elevator on to a belt conveyor, which takes it to the shale hopper. If the fine dirt is to be rewashed it is taken instead by a shoot to the third jigging machine. The coal recovered drops into the shoot leading to the sump, while the shale is raised to the shale hopper.

The water draining from the screens and belts flows into a clarifying tank, the base of which is formed into pyramidal separators where the coal mud or slime settles. The clear water from this tank is pumped back to the various jigging machines for use over again. The slime from the pyramidal separators flows at intervals by a channel to the slime holder placed near the ground level, whence it is pumped by a centrifugal pump and sprayed over the draining belts.

Alternating current of 500 volts and 50 periods is used for all motive power purposes. A complete electric lighting plant is installed also.

The buildings are wholly in steel. The floors are partly of concrete, partly in chequered iron plates. Large windows admit plenty of daylight. A central heating installation prevents freezing and adds to the workpeople's comfort.

M.3938.

260. MODEL (Scale 1 : 10) OF COARSE JIGGING MACHINE FOR COAL. Made by Herr Richard Braun, 1920.

This model represents a coarse jigging machine for washing coal as used at the Königin Marienhutte, Cainsdorf.

In coal dressing the conditions are reversed as compared with the concentration of other minerals, the specific gravity of coal being from 1·25 to 1·5, while the waste slate-shales with pyrites may vary from 2·25 to 5·0. In this case the useless material, being of higher specific gravity, forms the lower bed in screening, and the coal in washing rises to the top. Inv. 1920—736.

APPENDIX.

147a. MODEL (Scale 1 : 10) OF KEPS FOR SUPPORTING A MINE CAGE. Made by Herr Richard Braun, 1920.

This arrangement show the keps, or landing chairs for supporting a cage when loading or unloading at the station levels of a mine, patented in 1884 by A. Stauss. It consists of a bolt or sliding horn, which by a link attached to a bell-crank lever is operated by shaft and lever. Inv. 1920—732.

147b. MODEL (Scale 1 : 10) OF KEPS FOR RETAINING A MINE CAGE. Made by Herr Richard Braun, 1920.

This shows Haniel and Lueg's keps. The arrangement and purpose are similar to those of the adjoining model. Inv. 1920—733.

234a. MODEL (Scale 1 : 6) OF LÜHRIG COARSE JIGGING MACHINE. Made by Herr Richard Braun, 1920.

This is a type of coarse jigging machine for continuous separation of high-grade lead and zinc-blende ores much used on the Continent.

It consists of the usual box or hutch, divided by a partial partition into two compartments, in one of which a plunger is made to work up and down, and in the other is a fixed flat sieve. The operation of dressing ore in these machines is based on directing a current of water alternately upwards and downwards through a bedding of lead shot or some substance of similar density in fragments too large to drop through the screen. The upward current causes the mixed grains to stratify, the heavier below and the lighter above. The downward current or suction causes the smaller grains of heavy mineral to pass between the interstices of the larger grains, through the sieve into the lower portions of the hutch.

The crushed ore is fed in through the end sill. The lighter material is run off through the adjustable shutter down the side chute with the regulating lever and gate, on to tables or vanners for further treatment. The bucket wheel on the other side removes the coarse concentrates, and is driven from the eccentric shaft with belt pulley. Inv. 1920—735.

234b. MODEL (Scale 1 : 6) OF LÜHRIG FINE JIGGING MACHINE. Made by Herr Richard Braun, 1920.

This simple form of jig is used for the concentration of galena and zinc-blende ores; such machines are generally run in a series of 2, 4 or 6 hutches.

In the arrangements shown the line of shafting, eccentrics and plungers are placed at the back of the screening compartment. The crushed ore and wash-water is fed in from one end over the sill and overflows into the next of the series. The action of the alternating currents of water is the same as in the adjoining model, but there are no adjusting shutters for the regulation of the various products of concentration. The finer concentrates that have passed through the screens are drawn off from the bottom of the hutch through tubes into the launder beneath in the usual way. Inv. 1920—734.

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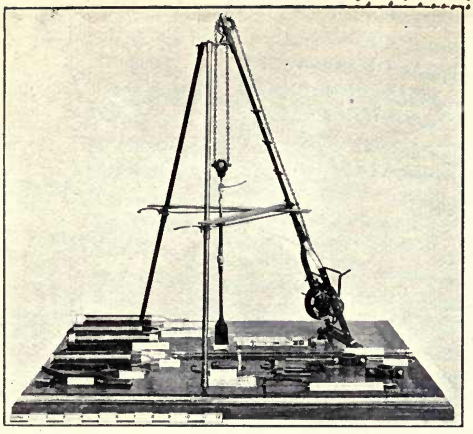

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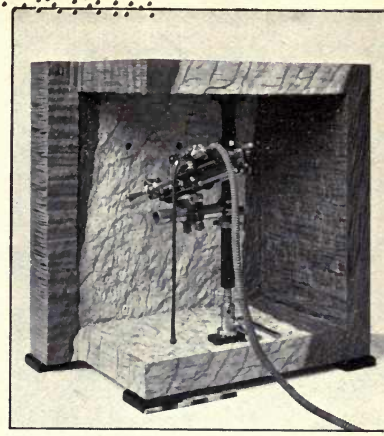

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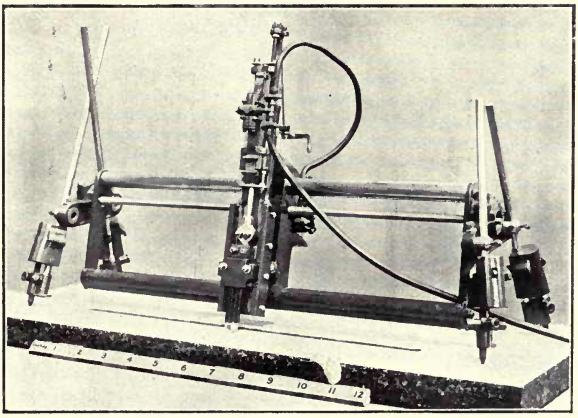

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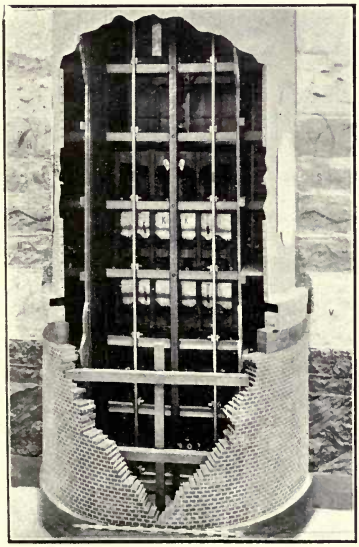

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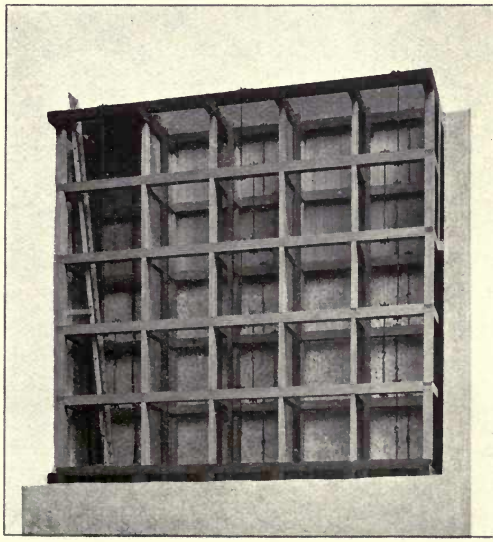

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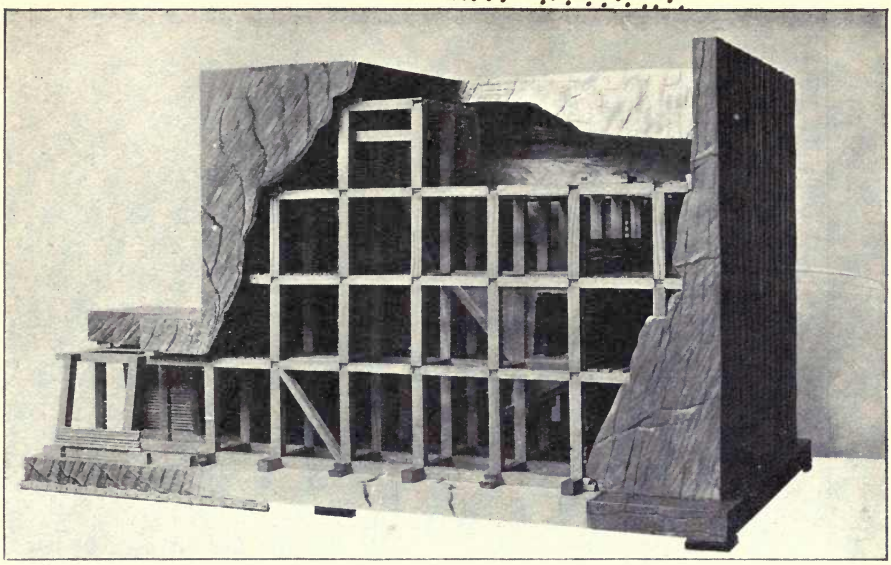

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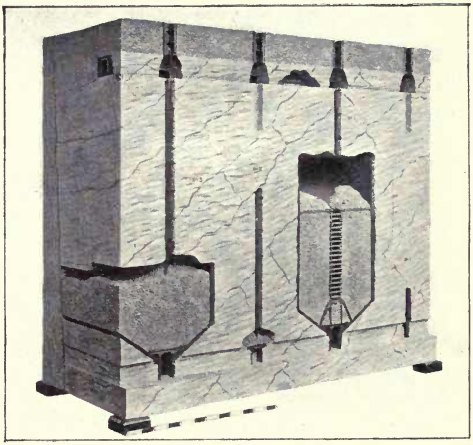

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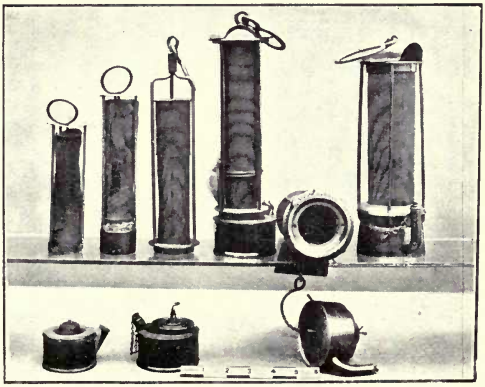

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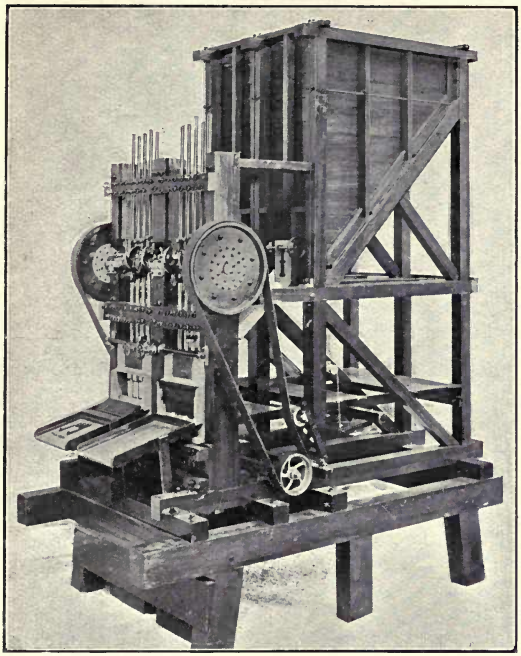

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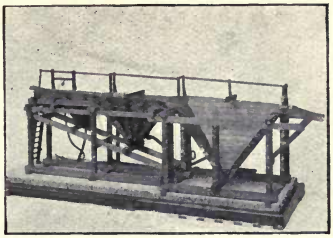

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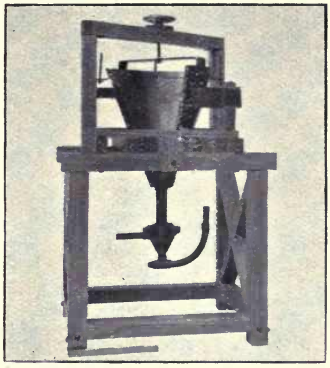

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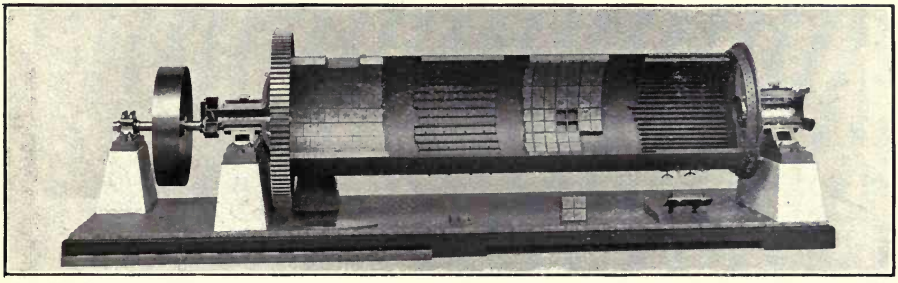

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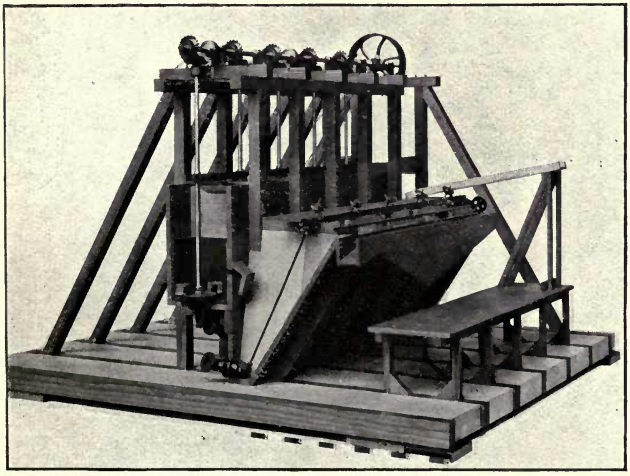

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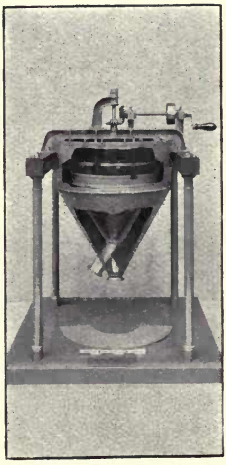

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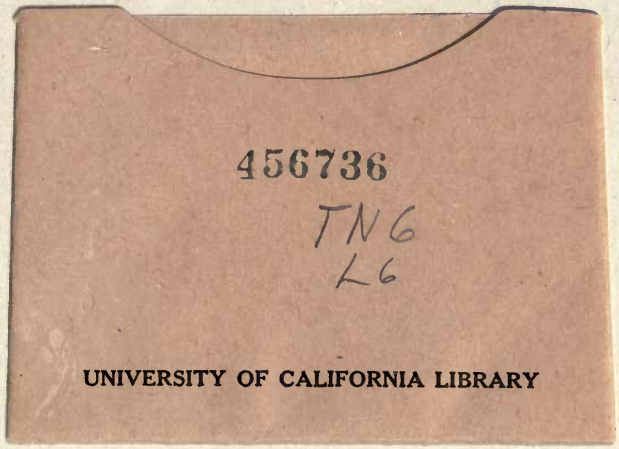
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